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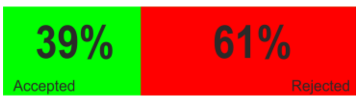

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Issue Article

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FEATURES OF CHANGES IN CLIMATIC CHARACTERISTICS OF THE REGIONS OF THE RUSSIAN ARCTIC ON THE LIFE OF INDIGENOUS PEOPLES

***Abstract**: in the article, the authors explore the features of the Arctic territories of the country, where more than half of the total number of indigenous peoples of the North live, the study of whose way of life becomes a separate object of scientific research. The purpose of this article is to study the development of scientific approaches to the study of the traditional economy of indigenous peoples of the North in the Arctic zone of the Russian Federation. The main research method was a comparative analysis of publications from the beginning of the 20th century to the present period of both domestic and international scientists studying the traditional types of economy of the indigenous peoples of the Russian Arctic. The analysis of publications was carried out in all available branches of scientific knowledge, not limited to a strictly economic focus, since the economy of the traditional economy of the indigenous peoples of the Arctic is inextricably linked with technology, technical and organizational equipment of farming and other areas. As a result of the study, high research activity on the topic under study was revealed, especially since the increased attention of government authorities to the development of the Arctic territories. However, it was determined that there is no comprehensive approach to studying the economic development of the economies of indigenous peoples living in the Russian Arctic.*

***Key words**: traditional economy, indigenous peoples, Russian Arctic, sustainable development, comparative analysis, indigenous peoples, Arctic aborigines, traditional way of life, types of traditional economic activities, Russian legislation, Association of Indigenous Peoples of the North, Siberia and the Far East of the Russian Federation.*

***Language**: English*

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Introduction

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The Arctic territory includes: A huge drifting ice shelf located in the Arctic Ocean, the northern waters of two oceans, the Pacific and the Atlantic, islands and archipelagos, including Greenland, the polar lands of North America and Eurasia, as well as many seas.

The official representative states on the shelf are: Russia, Canada, Denmark, Norway, USA. A fairly large part of the Arctic belongs to the Russian Federation.

The land territories of the Arctic zone of the Russian Federation are defined in accordance with the decree of the President of the Russian Federation dated May 2, 2014 No. 296 “On the land territories of the Arctic zone of the Russian Federation” and they are listed below, namely:

- Murmansk region (entirely).
- Nenets Autonomous Okrug (entirely).
- Chukotka Autonomous Okrug (entirely).
- Yamalo-Nenets Autonomous Okrug (entirely).
- Some territories of the north of the Komi Republic
- Some territories of the north of the Republic of Karelia (added by decree of the President of the Russian Federation of June 27, 2017 No. 287)
- Some territories of the north of the Republic of Sakha - Yakutia
- Some territories of the north of the Krasnoyarsk Territory
- Some territories of the north of the Arkhangelsk region
- Lands and islands located inArctic Ocean, specified in the resolution of the Presidium of the Central Executive Committee of April 15, 1926 “On declaring lands and islands located in the Arctic Ocean as the territory of the USSR” and other acts of the USSR.

Areas adjacent to the Atlantic and Pacific oceans are warmer and have more rainfall, while the climate of inland areas is colder and drier. In winter, the effects of cyclones from the Atlantic Ocean intensify in the Arctic regions. At this time, high air temperatures, strong winds, maximum precipitation and cloudiness. Anticyclones operate in the Siberian part of the Arctic regions.

Research shows that temperatures in the Arctic are rising twice as fast as in the rest of the world. This could lead to the extinction of many plant and animal species in the region. Warming also threatens the existence ofindigenous peoples of the Arctic. Arctic ice is of great importance for the Earth's climate system. Ice capreflects the sun's rays and thus prevents the planet from overheating. In addition, Arctic ice plays a large role inwater circulation systems in the oceans.

The activities of polar stations in the Arctic are the basis for monitoring natural processes in the environment: in the ocean and on land. These results are needed not only for direct use in current human activities in the Arctic, but also for accumulating and improving the base of long-term observations, which are necessary for studying natural processes that influence the climate, and therefore the prospects for human life throughout the globe.

Back in the 1870s, it became clear that the study of the territories of the Arctic zone of the Russian Federation by scattered expeditions could not produce results that would allow conducting fundamental research in the Arctic Ocean zone. In a word, the idea of creating some kind of permanently operating polar stations that systematically take readings was in the air.

When talking about Russian polar stations in the Arctic, people most often recall their rapid development during the Soviet period. However, Russia began to use them much earlier. During the First International Polar Year (1882-83), two Russian stations participated in research - Malye Karamakuly on Novaya Zemlya and Sagastyr in the Lena delta. In 1913-1915, 4 more polar stations began operating - Yugorsky Shar, o. Vaygach, Marre-Sale station on the Yamal Peninsula and on the island. Dixon. Due to harsh climatic conditions and a rather inaccessible location, weather stations are unfortunately not so common in the Arctic region. In the USSR, the Arctic zones were provided with much more polar stations than they are now. The number of polar stations in the Arctic decreased significantly in the 90s of the last century. Lack of funding and lack of interest in this sector in Russia has led to the closure of up to 50% of stations. Today, unfortunately, there are not many operating Arctic stations, namely.

- Arctic Research Station - Labytnangi, Yamalo-Nenets Autonomous Okrug.
- Belomorskaya biological stationMoscow State University - Primorsky village, Loukhsky district, Republic of Karelia.
- Valkarkay - Chaunsky district, Chukotka Autonomous Okrug.
- Willem Barents - Dikson, Krasnoyarsk region.
- Hydrometeorological station named after. M.V. Popova - Bely Island, Kara Sea.

- Dikson hydrometeorological station - Dikson village, Krasnoyarsk Territory.
- Yenisei ecological station "Mirnoye" - Mirnoye village, Turukhansky district, Krasnoyarsk region.
- Izvestia Central Executive Committee - Troinoy Island, Izvestiya Central Executive Committee Islands, Kara Sea.
- Lena-Nordenskiöld - Bank of the Bykovskaya channel of the Lena River, north of Tiksi, Yakutia.
- Malye Karmakuly - Yuzhny Island, Novaya Zemlya archipelago.
- Marre-Sale - North of Cape Marre-Sale, Yamal Peninsula, Yamalo-Nenets Autonomous Okrug.
- Cape Baranova (formerly Prima) - Cape Baranova, Bolshevik Island, Severnaya Zemlya archipelago.
- Cape Zhelaniya - Cape Zhelaniya, on the Northern Island of the Novaya Zemlya archipelago.
- Ernst Krenkel Observatory - Hayes Island, Franz Josef Land archipelago.
- Vize Island - Vize Island, Kara Sea.
- Wrangel Island - Rogers Bay, Wrangel Island.
- Golomyanny Island - Golomyanny Island, Sedov Archipelago, part of the Severnaya Zemlya archipelago.
- Samoilovsky Island - Samoilovsky Island, Lena River delta, Yakutia.
- Polar geocosmophysical observatory "Tiksi" - Tiksi village, Yakutia.
- North-Eastern Scientific Station - Chersky Village, Yakutia.
- Solnechnaya - Solnechnaya Bay, Bolshevik Island, Severnaya Zemlya archipelago.
- Stolbovoy - Stolbovoy Island, Laptev Sea.
- Stolbovoy Cape - South Island, Novaya Zemlya archipelago.
- Chelyuskin - Cape Chelyuskin, Taimyr, Krasnoyarsk Territory.

There are also drifting polar stations in the Arctic.

Therefore, in this regard, studies are being conducted on the life of indigenous peoples of the Russian Arctic in the context of industrial development. State policy in the field of subsoil use, hydrocarbon production, and the very presence of industrial companies in the Arctic regions today have a powerful impact on the livelihoods of northern aborigines, determining the need to adapt to existing conditions and, to a large extent, socio-economic and ethnocultural prospects. The world community is concerned about the situation of indigenous peoples and is looking for ways to solve their problems, ensure free development, preserve cultures and languages, use the achievements of modern society and modernization. This can be judged from a number of UN documents, numerous international conferences, and a large number of scientific studies. The main focus of the UN in 2013 was on the topic "Creating Indigenous Alliances: Compliance with Treaties, Agreements and Other Constructive Agreements." Its isolation from the entire spectrum of issues affecting indigenous peoples is not accidental. The living conditions, lifestyle, and worldview of these peoples place them in a special position, which the world community increasingly has to take into account. In the Russian Federation, the issue of "control over one's destiny" is also relevant for indigenous peoples. Indicative are the numerous discussions of this problem in the State Duma and the Federation Council and the adoption of such important documents as "Fundamentals of state policy in the Arctic for the period until 2035", "Strategy for the development of the Arctic zone of the Russian Federation and ensuring national security for the period until 2035"). state program "Socio-economic development of the Arctic zone of the Russian Federation for the period until 2035." The authors set themselves the following tasks: to study the interaction of indigenous peoples of the North and industrial companies in the context of international, national, corporate and customary law; consider the current economic and sociocultural practices of the Aboriginal people; identify risks associated with industrial development and propose ways to overcome them. This approach is new for domestic science and allows us to raise the question of responsibility for the Arctic, as well as consider the social and environmental policies of companies as a platform for establishing a dialogue with indigenous peoples. Today in the Russian Federation, indigenous organizations of indigenous peoples of the North demand the right to prior, informed and voluntary consent to carry out industrial activities in areas of traditional residence and to receive fair compensation for damage caused. Industrial companies have their own vision of this problem. In some regions, particularly where multinational corporations operate, interactions between indigenous peoples and businesses are established as part of broader social dialogue. Aboriginal protests are evidence of the existing contradictions between traditional and industrial environmental management, folk beliefs, skills and utilitarian-commercial knowledge and approaches to the environment and its resources. That is why achieving a genuine partnership between indigenous peoples and industrial companies in the Russian Arctic today is becoming one of the conditions not only for the social well-being of representatives of these peoples, but also for achieving stability in Russian society, as well as protecting the geopolitical interests of the state. In our book, we sought to reflect the positions of the main actors in the processes of interaction in the Arctic zone of Russia. For a detailed analysis, two Arctic regions were selected - the Yamalo-Nenets and Chukotka

Autonomous Okrugs. The authors drew up a research program that included interviews with different groups of aborigines (reindeer herders, fishermen, marine hunters, employees of agricultural enterprises, teachers, doctors), with representatives of government agencies and industrial enterprises. The work was carried out in Moscow, Salekhard, Anadyr, in regional centers and villages of the Yamalo-Nenets Autonomous Okrug and Chukotka Autonomous Okrug, as well as in the camps of reindeer herders, fishermen, and hunters. The formulation of questions and interpretations of answers were based on the authors' previous work experience in the North. Each ethnographic study allows us to take a different look at the problems from the point of view of new practices that arise in the process of industrial development of the Arctic, so we consider this book as an analysis of a certain stage of interaction between indigenous peoples and industrial companies. The choice of study regions was determined by a number of factors. First of all, the fact that large-scale industrial projects related to the development of natural resources are being developed and implemented in these autonomous okrugs. At the same time, nomadic reindeer herders, sea hunters and fishermen live there. Among them, the original features of ethnic culture have been preserved to this day in their most "pure" form. At the same time, against the backdrop of industrial expansion, the traditional way of life of the northern aborigines is being transformed. They were faced with a choice: either preserve and develop their unique culture, or abandon it and live like the vast majority of the country's citizens. The ethnic situation in the Yamalo-Nenets Autonomous Okrug has been the focus of attention of the authors since 2008. The Yamal and Tazovsky districts of the district became the base for our research. Their choice is due to the dominant population of indigenous peoples and active industrial development. Great attention to Yamal among scientists made it possible to attract additional information and take into account the positions of other authors on the topics raised in the work. Another region of the study was the Chukotka Autonomous Okrug. The impact of industrial development on the indigenous peoples of Chukotka has been studied to a lesser extent, although indigenous public organizations have accumulated some experience in interacting with mining companies. In 2023 Field research was carried out in the city of Anadyr and the Chaunsky, Anadyrsky, Bilibinsky, Providensky districts of the Chukotka Autonomous Okrug. As in the Yamalo-Nenets Okrug, this data was collected among indigenous communities, in various state and municipal government structures, and industrial companies. The subject of special consideration was the activities of the Kupol Fund, created by Kinross to financially support the most promising projects in the field of traditional environmental management, preservation of ethnic culture, and languages of the indigenous peoples of Chukotka. The role of public organizations of indigenous peoples in the formation of new relationships with industrial companies is shown.

Main part

Russia is the first country to use drifting polar stations. Each such station is a complex of station houses installed on a drifting Arctic ice floe, in which expedition participants live, and the necessary equipment. For the first time, such a cheap and effective way of exploring the Arctic was proposed in 1929 by Vladimir Wiese, a researcher who worked at the Arctic and Antarctic Research Institute. Thanks to this creation of drifting stations, Russian scientists were able to explore the Arctic all year round. The first drifting expedition, called "North Pole", landed at the pole on May 21, 1937. The data obtained during the expeditions expands scientists' knowledge of the processes occurring in the natural environment of the Central Arctic and will help explain the causes of global climate change. Weather conditions in different parts of the Arctic are quite different. Cyclones, melting glaciers, polar nights and even solar radiation play a role in their variability.

To carry out the study, it is necessary to create a database obtained from Arctic stations to track changes in the region. To study, we will consider two polar stations on the territory of the Russian Federation: Vise Island and the polar station of Valkarkay.

Station coordinates: Valkarkai station70°05′06″ n. w. 170°55′21″ E. d.;Vize island station79°30′ N. w. 76°54′ E. d.The distance between stations is 2,564 km.

Figure 1. Polar stations Valkarkay and Vize Island on the geographical map of the Arctic zone of the Russian Federation.

Vize Island is located in the northern part of the Kara Sea, stretching from southeast to northwest for 22.5 km, the island has a width of 5.5 km. The coastline of the island is very slightly indented. Its shores are gentle and only near the sea, mainly in the northwestern part, in some places they form low sandy cliffs. The eastern cape is located 10 km from the station, the western (turning) cape, on which a navigation sign is installed. 2 km. The island of Vize is surrounded on all sides by a coastal rampart of stones and small pebbles ranging from 7 to 30 m wide. In some places the rampart is an embankment, in others there are separate piles of pebbles at varying distances from the water's edge. The territory of the island is completely covered with hills, the height of which reaches 15-30 m. The hills are separated by narrow hollows, which in the summer are the beds of streams and rivers. Closed depressions are filled with melt water, forming shallow lakes, most of which dry up in summer and freeze to the bottom in winter. Coastal lakes are usually salty. There are two lagoons in the southwestern and northwestern parts of the island's coast. The first is separated from the sea by sandy and rocky spits, the second by a wide isthmus.

The soil is sandy-clayey with inclusions of broken flagstone. The island is located in the Arctic tundra zone. There is almost no vegetation: reindeer moss grows in patches, there are isolated hummocks covered with lichens, a few colors. There are no settlements on the island; the delivery of necessary products is carried out during the navigation period by ship, using a helicopter.

The climate here is no less harsh. Weather features are determined by the island position of the station. The average long-term air temperature is -13.6 C. The average monthly air temperature in the warmest month. July is +0.5 C, at its coldest. March -26.9 C. The absolute minimum temperature is -52.0 C. The average long-term relative air humidity is 90%. In the station area, 242 mm of precipitation falls throughout the year. The prevailing wind direction is southeast with an average annual speed of 6.4 m/s. A stable snow cover forms in mid-September (13th), its final melting occurs at the end of June (26th). Summer is short and cold.

Since November 1, 1945, a hydrometeorological polar station, one of the northernmost in the world, has been operating on the southern coast of the island. The polar station is located on the southern coast of Vize Island in the Kara Sea. The Wiese marine hydrometeorological station began its work on November 1, 1945. Since September 1956, the station's program has included aerological sounding of the atmosphere. Since March 20, 1957, the duration of sunshine has been recorded using a heliograph. Actinometric observations have been carried out since September 1957. On October 28, 1958, observations of ice and frost deposits on an ice machine began. In September 1988, observations began using exhaust soil depth thermometers TPV-50 at depths of 0.2, 0.4 and 0.8 m. On July 18, 1993, the station used the BRS-1 mercury-free barometer.

Figure 2. Vize Island on the map of the Arctic Ocean.

Valkarkay is a remote polar station on the Arctic coast of the East Siberian Sea, within the Chaunsky district of the Chukotka Autonomous Okrug of Russia. Located on the spitpolar station of the same name·created in 1932. It is located on a spit separating the Valkarkay lagoon from the sea.The weather station is located behind a very swampy pass, which makes it extremely difficult to get there. In winter you can get to it by snowmobile, and in summer only by a powerful all-terrain vehicle like Trekol, and even then - without guarantees. There have been many cases where a car gets stuck in the middle of the road. However, the inhabitants of the station are accustomed to living independently and rarely travel to Pevek. But the main difficulty is that the station is located on the shores of the Arctic Ocean and is separated from Pevek Chukotka Plateau, with heights in this part up to700-1100 meters.Once a year, a ship docks at Valkarkai, unloading canned food, batteries and everything you need for life.

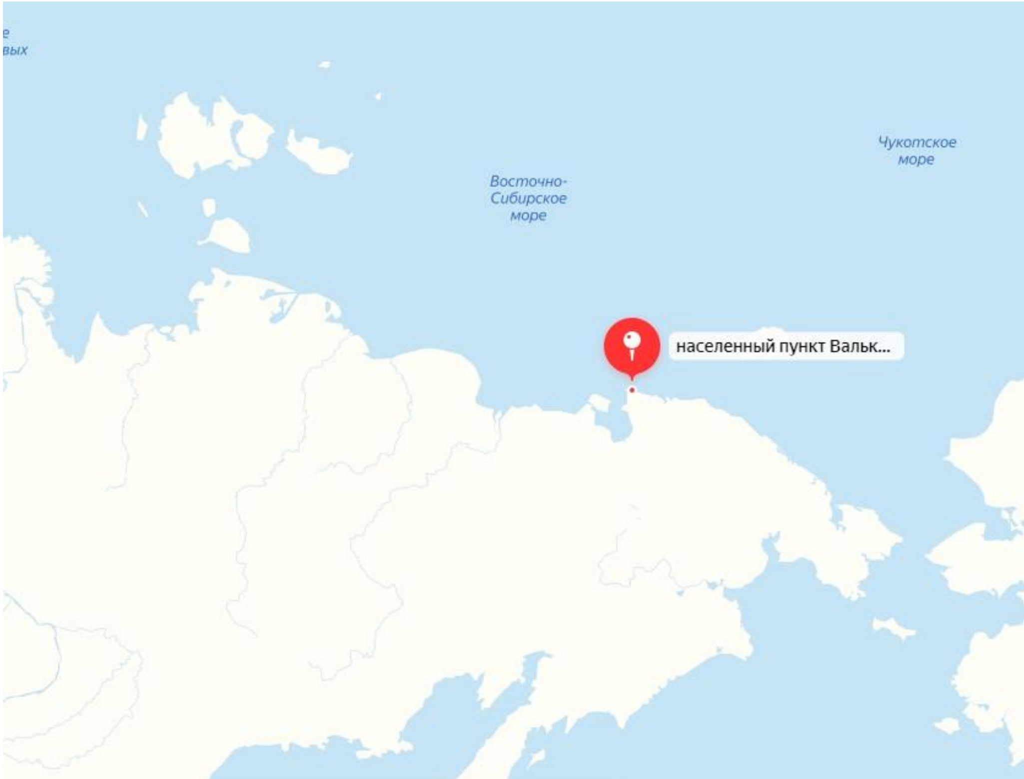


Figure 3. Valkarkay station on the geographical map of Russia.

The period from 2018 to 2023 was selected for the study. at the Valkarkai station and the Wiese Island station. Meteorological data on air temperature, atmospheric pressure, humidity, amount of precipitation and data on wind speed and direction for each day, selected from Internet resources, were used as initial data.

Table 1. Sorted atmospheric pressure data at Valkarkay station for each year by month.

March			April			May		
2018 -2019	2020-2021	2022-2023	2018-2019	2020-2021	2022-2023	2018-2019	2020-2021	2022-2023
758.6	755.8	772.9	759.7	757.0	757.0	758.9	755.5	760.5
765.6	756.4	763.9	756.7	754.7	755.5	762.8	754.6	763.4
761.2	757.0	763.0	755.8	755.8	754.9	763.0	752.3	766.3
761.7	756.1	759.4	758.4	756.5	751.0	757.0	754.3	765.3
762.7	758.5	743.2	762.0	752.7	753.6	754.7	758.7	761.2
762.0	759.0	741.1	764.3	754.1	760.8	757.4	762.4	756.7
761.0	751.6	757.8	767.5	756.2	761.5	758.5	761.3	757.1
765.2	746.8	759.1	769.0	761.2	764.8	762.4	757.6	756.6
761.8	753.2	762.1	769.0	764.7	768.4	761.2	759.1	758.4
763.0	759.5	769.6	767.2	765.0	770.4	757.5	759.9	768.1
764.0	767.9	770.2	768.5	762.1	764.5	756.7	758.5	767.9
764.9	772.0	769.6	769.5	758.2	764.0	756.2	762.5	762.6
762.1	765.0	757.3	763.8	753.8	759.1	756.6	763.5	763.3

765.7	766.3	751.5	762.3	751.0	768.7	757.0	761.9	764.2
764.1	770.9	756.2	758.0	752.4	760.4	754.6	763.0	759.8
762.4	770.8	761.0	757.3	759.1	762.1	753.1	760.2	762.8
769.5	765.1	759.5	756.1	764.4	763.3	754.6	759.4	765.1
768.1	763.3	761.8	755.8	769.0	761.0	757.9	755.8	768.7
771.7	761.4	764.8	770.3	772.2	758.9	764.0	761.8	765.3
771.1	759.1	766.6	767.1	768.1	757.3	765.3	760.0	758.3
758.8	763.5	764.9	763.1	761.5	758.0	765.2	759.5	756.4
747.7	771.4	757.9	758.8	754.9	758.4	761.5	761.2	760.0
755.6	767.5	754.4	763.6	764.8	761.2	758.8	757.7	766.2
759.1	761.8	754.1	761.9	769.3	765.1	759.1	759.7	768.4
770.4	765.5	757.3	758.2	773.0	766.0	761.8	760.8	759.7
776.8	765.9	761.5	754.0	774.1	762.8	763.2	766.6	763.0
778.4	764.1	760.6	754.1	773.9	762.1	764.1	764.0	763.0
775.9	768.2	755.1	756.1	773.9	763.9	762.2	760.2	762.2
770.3	761.7	762.8	756.6	775.0	767.6	758.8	757.0	761.2
773.7	746.5	759.7	754.6	771.7	769.0	758.1	760.8	761.8
776.7	758.5	750.2				759.9	761.1	761.1

To study the characteristics of temporal variability, the following methods of time series analysis were used in the work.

Arithmetic mean and standard deviation. The arithmetic mean value of the statistical series (X) characterizes its equilibrium point during various fluctuations. Calculated using the formula:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{n} x_i$$

The standard (or mean square) deviation (σ) characterizes the average dispersion of the values of a series from the arithmetic mean. Standard deviation is related to variance (D). Calculated using the formula:

$$\sigma = \sqrt{D}$$

Where D is variance

$$D = \frac{1}{N}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

limits of the confidence interval of the mean value, in the case of 95%: x− 1.96 ×σ/n in the case of +95%: x + 1.96 ×σ/n

Also, between points with average values, you can calculate the correlation using the following formula:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

And the significance of the correlation was determined based on the calculation of the standard

random error:

$$\sigma_r = \frac{1 - r^2}{\sqrt{n-1}}$$

Analysis of meteorological parameters at the station

Air temperature analysis

Let's consider data on air temperature in the period from March to February at two stations from 2018 to 2023.

Table 2 presents calculated data on the average temperature, minimum and maximum temperature, standard deviation of temperature for each month of the period under consideration at the Valkarkai station.

Table 2. Calculated air temperature data at Valkarkai station.

	Average °C	RMS	Min°C	max°C
		2018-2019		
March	-14.4	6.9	-29.6	3.4
April	-9.5	6.2	-23.4	2.2

May	-2.8	3.2	-13.4	5.5
June	1.7	2.8	-2.7	16.7
July	6.9	3.9	1.2	20.3
August	7.2	4.1	-1.3	20.2
September	2.5	2.2	-2.2	12.1
October	-3.5	4.6	-14.5	7.7
november	-9.0	6.3	-23.8	3.6
December	-15.7	6.7	-30.8	-2.7
January	-21.1	8.1	-34.1	3.1
February	-16.2	3.1	-23.4	-8.0
		2020-2021		
March	-24.5	7.1	-37.6	-3.0
April	-10.8	4.3	-20.2	0.3
May	-6.6	5.2	-20.5	2.1
June	1.2	2.5	-5.8	12.2
July	5.0	5.8	-0.9	23.3
August	3.6	4.4	-2.4	20.0
September	6.8	4.2	-1.1	19.5
October	-3.4	6.6	-18.6	13.4
	Average °C	RMS	Min°C	max°C
november	-16.9	5.9	-31.1	-5.4
December	-26.5	6.9	-36.4	-5.3
January	-25.3	3.5	-34.1	-12.0
February	-24.6	5.6	-38.2	-5.2
		2022-2023		
March	-22.0	6.1	-36.9	-8.7
April	-14.3	7.0	-28.3	2.5
May	-5.2	4.0	-15.8	4.8
June	2.6	3.7	-2.8	16.9
July	5.5	4.2	-0.8	21.9
August	4.4	2.9	-1.0	14.5
September	1.6	2.2	-4.1	9.4
October	-4.2	4.0	-17.2	1.7
november	-11.6	6.3	-27.2	0.1
December	-19.0	6.5	-32.9	-5.9
January	-23.9	5.8	-35.7	-0.5
February	-28.6	6.1	-39.8	-11.3

Based on the data, the lowest air temperature was recorded in February 2023 and amounted to -39.8°C, and the highest in July 2019 and amounted to 23.3°C. It should be noted that during this period at the Valkarkay station, the lowest temperatures were most often observed in February, and the highest temperatures in July. Let us graphically present the minimum, maximum and average air temperature values at the Valkarkai station and draw a trend line (Figure 4 a, b, c).

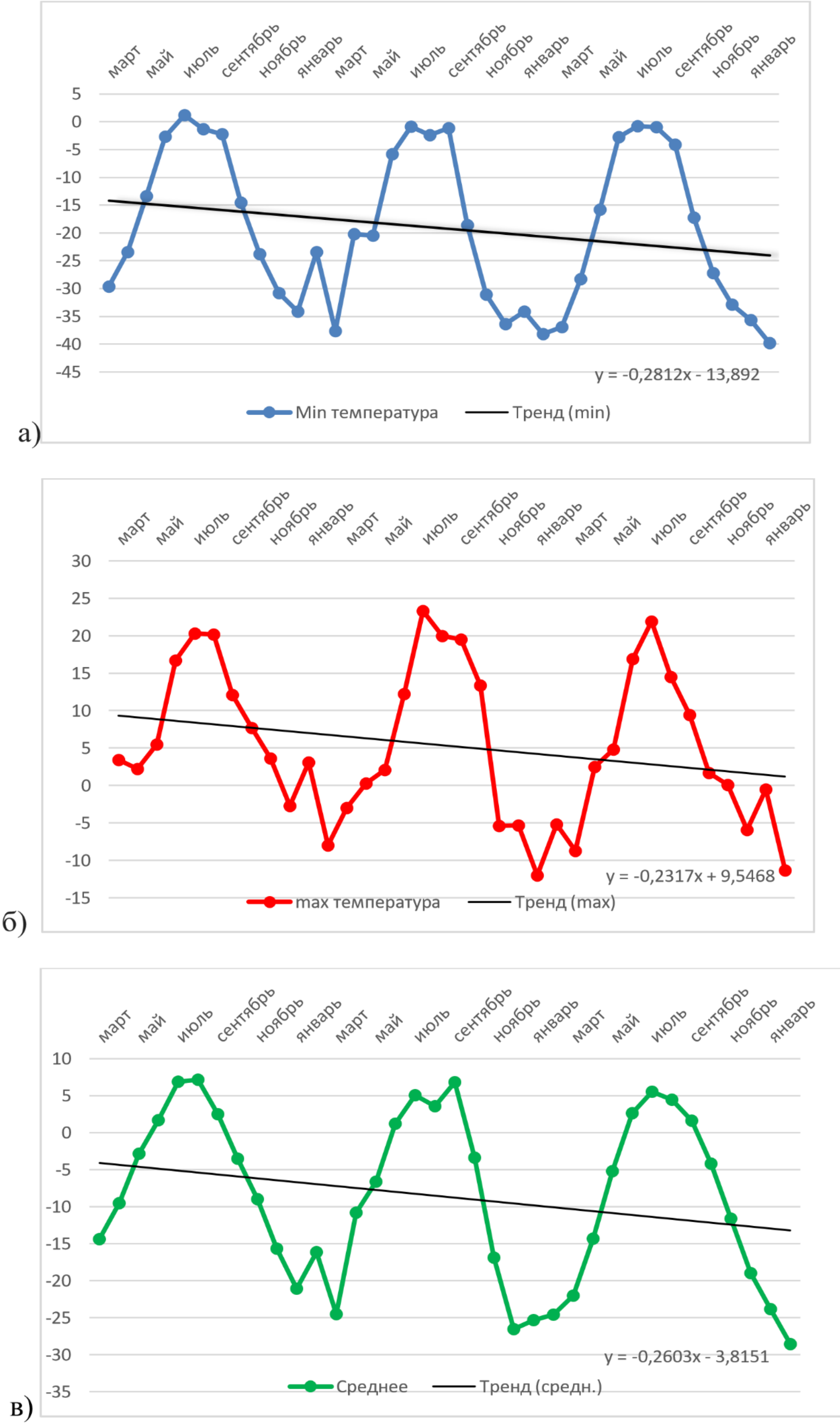


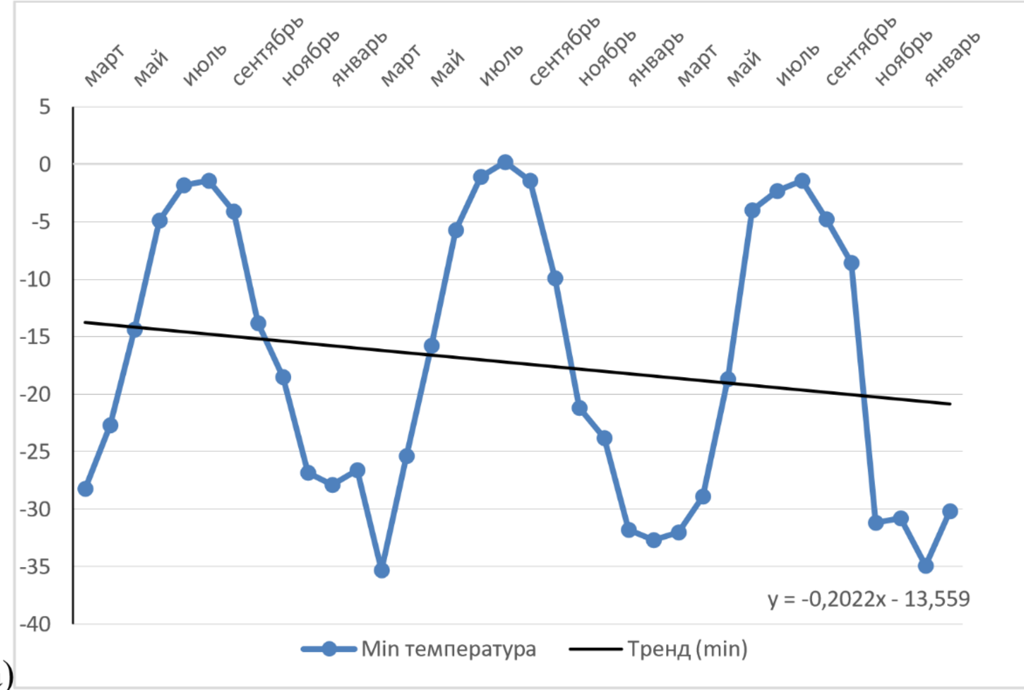
Figure 4. Minimum, maximum and average air temperature values at Valkarkai station, °C

Having analyzed the data obtained from Figure 2 (a, b, c), we can conclude that in all cases the slope of the trend line is almost identical. For minimum temperatures it is 15.71°, for maximum it is 13.05°, and for average it is 14.59°. Thus, in all cases it contributes to the formation of variability in the original series. Table 3 presents calculated data on the average temperature, minimum and maximum temperature, standard deviation of temperature for each month of the period under consideration at the Vise Island station.

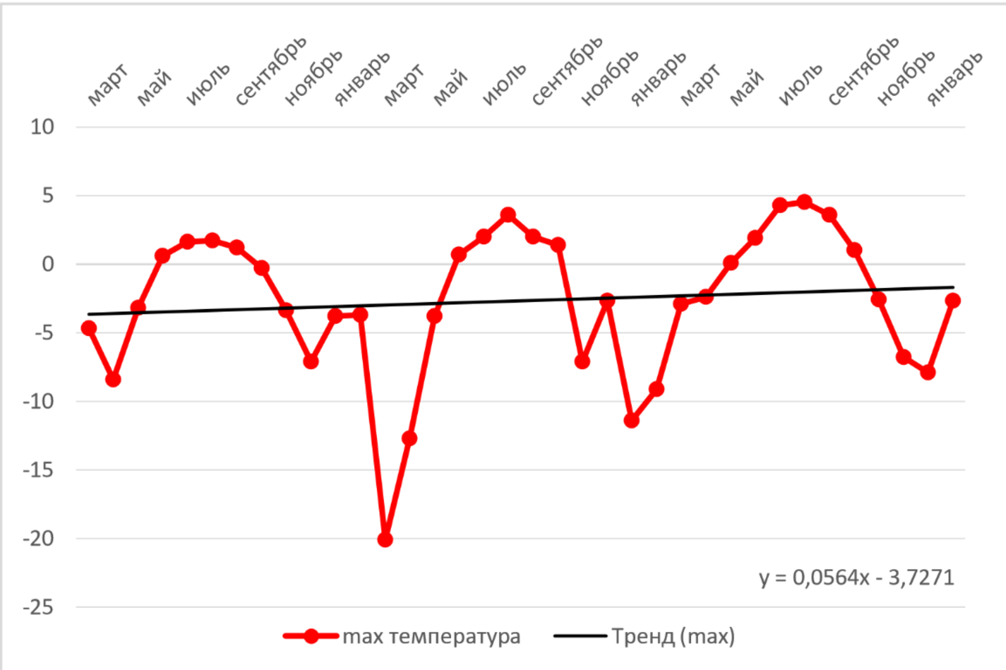
Table 3. Calculated data on air temperature at the Vise Island station.

	Average °C	RMS	Min °C	max °C
		2018-2019		
March	-19.4	6.8	-28.2	-4.7
April	-15.1	3.4	-22.7	-8.4
May	-10.1	3.2	-14.4	-3.2
June	-1.7	1.4	-4.9	0.6
July	-0.1	0.8	-1.8	1.6
August	0.3	0.9	-1.4	1.7
September	-1.1	1.4	-4.1	1.2
October	-5.5	3.4	-13.8	-0.3
november	-12.5	4.5	-18.5	-3.4
December	-19.4	4.8	-26.8	-7.1
January	-18.9	6.1	-27.9	-3.8
February	-17.4	6.7	-26.6	-3.7
		2020-2021		
March	-27.4	4.2	-35.3	-20.1
April	-19.2	3.2	-25.4	-12.7
May	-7.6	2.9	-15.8	-3.8
June	-0.8	1.5	-5.7	0.7
July	0.2	0.6	-1.1	2.0
	Average °C	RMS	Min °C	max °C
August	2.0	1.0	0.2	3.6
September	0.3	0.9	-1.4	2.0
October	-2.9	3.5	-9.9	1.4
november	-13.9	3.9	-21.2	-7.1
December	-12.9	6.4	-23.8	-2.7
January	-24.1	4.9	-31.8	-11.4
February	-23.3	6.8	-32.7	-9.1
		2022-2023		
March	-19.3	7.9	-32.0	-2.9
April	-16.3	6.1	-28.9	-2.4
May	-6.9	4.2	-18.7	0.1
June	-0.6	1.0	-4.0	1.9
July	0.6	1.2	-2.3	4.3
August	1.2	1.2	-1.4	4.5
September	-0.4	1.5	-4.8	3.6
October	-3.3	2.2	-8.6	1.0
november	-13.7	7.7	-31.2	-2.6
December	-20.9	4.1	-30.8	-6.8
January	-24.2	6.5	-34.9	-7.9
February	-16.7	7.8	-30.2	-2.7

Based on the data, the lowest air temperature was recorded in March 2018 and amounted to -35.3°C, and the highest in August 2023 and amounted to 4.5°C. It should be noted that during this period at the Vise Island station, the lowest temperatures were most often observed in March, and the highest temperatures in July-August. Let us graphically present the minimum, maximum and average air temperature values at the Vise Island station and draw a trend line (Figure 5 a, b, c).



a)



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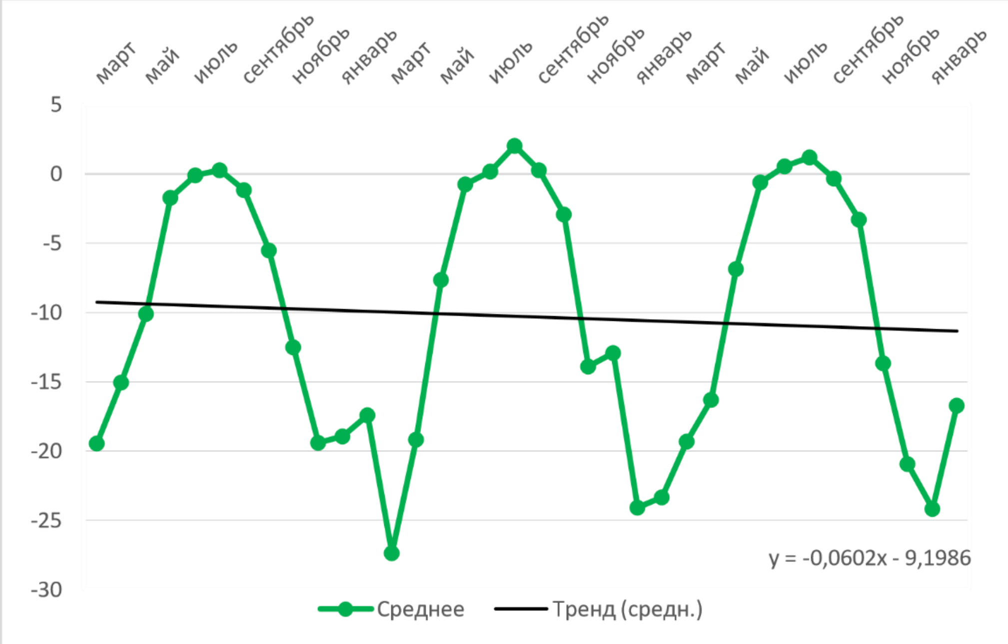


в)

Figure 5. Minimum, maximum and average air temperatures at the Vise Island station. °C

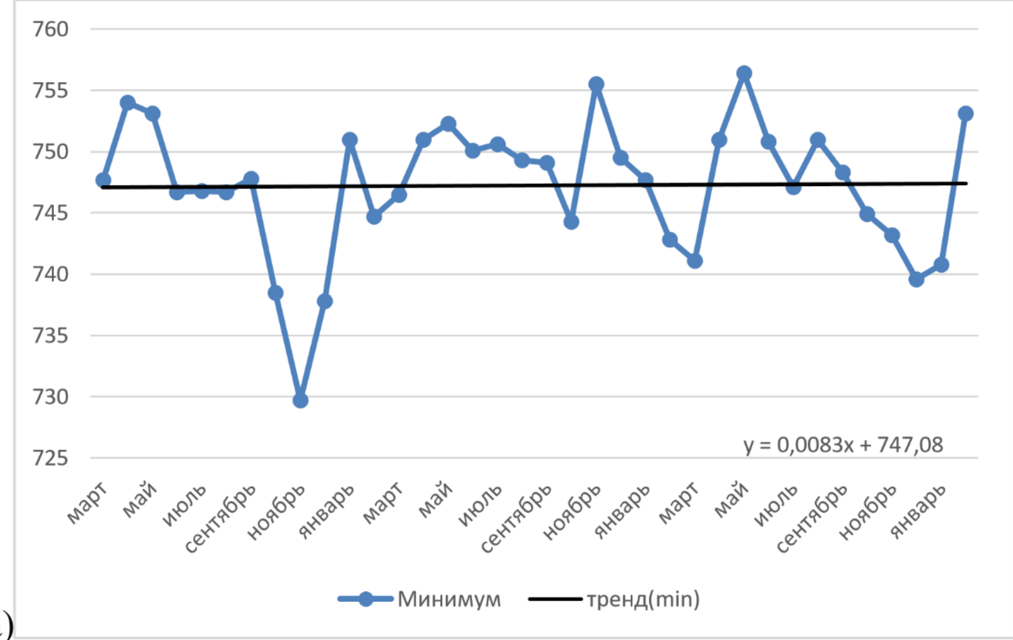
After analyzing the data obtained from Figure 5 (a, b, c), we can conclude that the trend lines have different slope angles. For minimum temperatures it is 11.43°, for maximum it is 2.86°, and for average it is 3.45°. In the case of maximum and average air temperatures, the slope of the trend is not significant, and in the case of minimum air temperatures, the trend contributes to the formation of the variability of the original series. In Table 4. calculated data on atmospheric pressure - maximum, minimum, average monthly atmospheric pressure and standard deviation for each month of the period under consideration at the Valkarkai station.

Table 4. Calculated data on atmospheric air pressure at Valkarkai station.

	Average (mm.Hg)	RMS	Min (mmHg)	Max (mm.Hg)
			2018-2019	
March	765.5	6.8	747.7	778.4
April	761.3	5.3	754.0	770.3
May	759.4	3.4	753.1	765.3
June	756.8	4.3	746.7	764.3
July	755.6	4.9	746.8	764.7
August	758.5	5.2	746.7	766.4
September	756.7	4.6	747.8	764.7
October	757.2	6.5	738.5	766.2
November	755.4	9.8	729.7	773.5
December	761.9	11.0	737.8	782.1
January	764.3	7.4	751.0	778.2
February	761.6	8.8	744.7	776.7
			2020-2021	
March	761.6	6.7	746.5	772.0
April	762.7	7.8	751.0	775.0
May	759.7	3.1	752.3	766.6
June	760.0	5.9	750.1	771.2
July	757.7	3.6	750.6	765.1
August	760.5	4.7	749.3	768.4
September	758.0	3.8	749.1	763.1
October	759.7	6.2	744.3	769.5

November	766.1	6.6	755.5	780.8
December	764.2	6.5	749.5	775.6
	Average (mm.Hg)	RMS	Min (mmHg)	Max (mm.Hg)
January	763.0	6.3	747.7	771.0
February	756.6	6.6	742.8	766.7
		2022-2023		
March	759.6	7.1	741.1	772.9
April	761.7	4.8	751.0	770.4
May	762.4	3.6	756.4	768.7
June	761.6	4.6	750.8	769.3
July	755.0	3.9	747.1	762.2
August	763.4	6.0	751.0	775.6
September	756.7	4.7	748.3	765.1
October	759.1	6.8	744.9	768.1
November	761.0	6.7	743.2	770.6
December	761.4	9.2	739.6	780.2
January	762.4	8.7	740.8	777.1
February	766.0	6.1	753.1	778.9

Let us graphically present the minimum, maximum and average values of atmospheric air pressure at the Valkarkai station and draw a trend line (Figure 6 a, b, c).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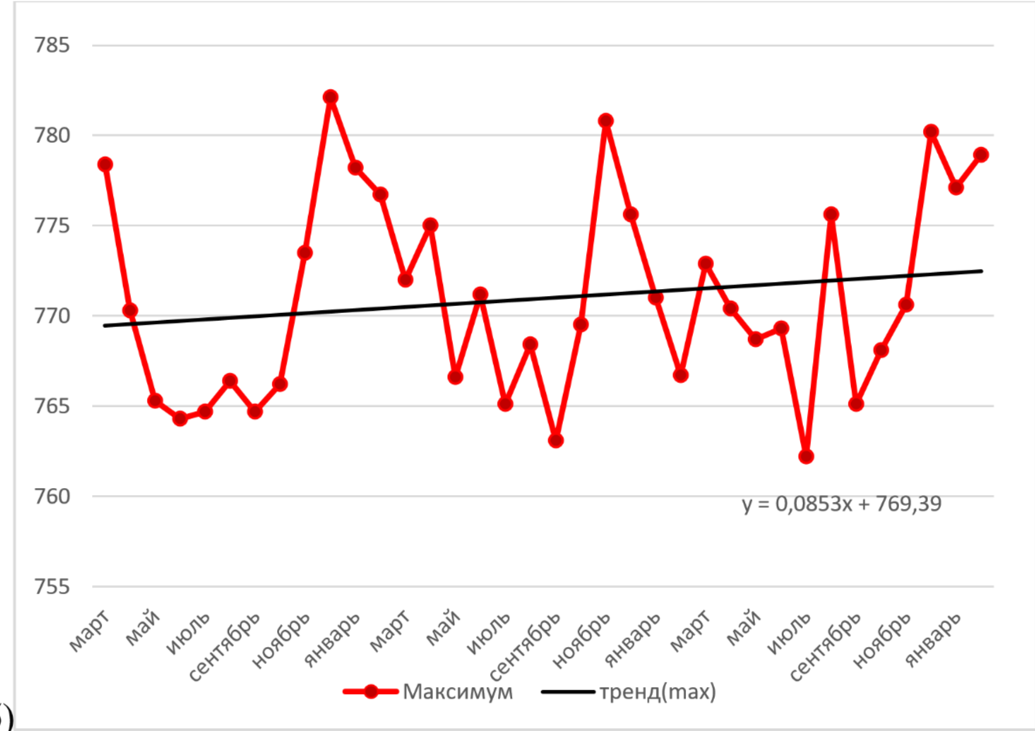
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январь
Максимум
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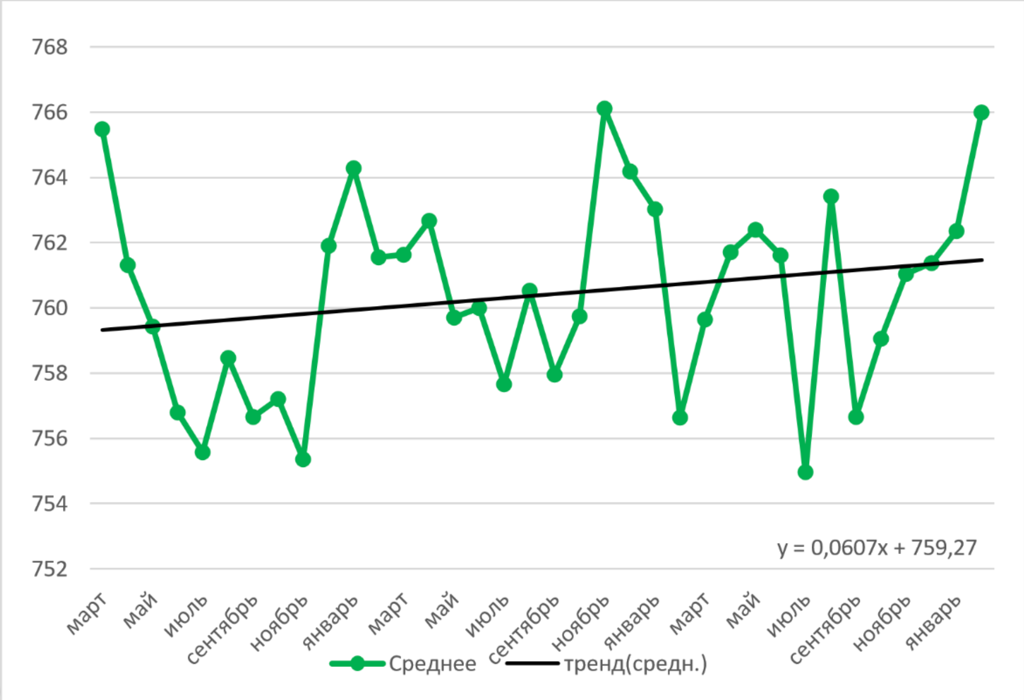


Figure 6. Minimum, maximum and average values of atmospheric pressure at Valkarkay station.

Having analyzed the data obtained, we can conclude that the lowest pressure at the Valkarkay station for the entire study period is 729 mmHg. observed in November 2019 The highest pressure was recorded in December 2022. and amounted to 782 mmHg. The slope of the trend line is insignificant in all cases. For minimum values it is 0.48°, for maximum 4.86°, and for average 3.47°. Thus, in the case of minimum values of atmospheric pressure, the trend does not make any contribution to the formation of the variability of the original series.

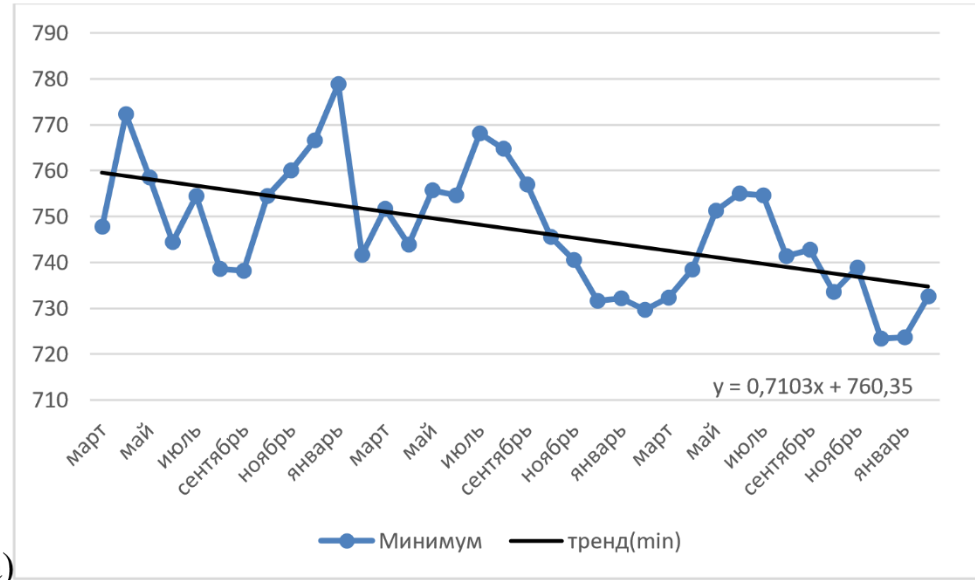
In table 5. calculated data on atmospheric pressure - maximum, minimum, average monthly atmospheric pressure and standard deviation for each month of the period under consideration at the Vise Island station.

Table 5. Calculated data on atmospheric air pressure at the Vise Island station.

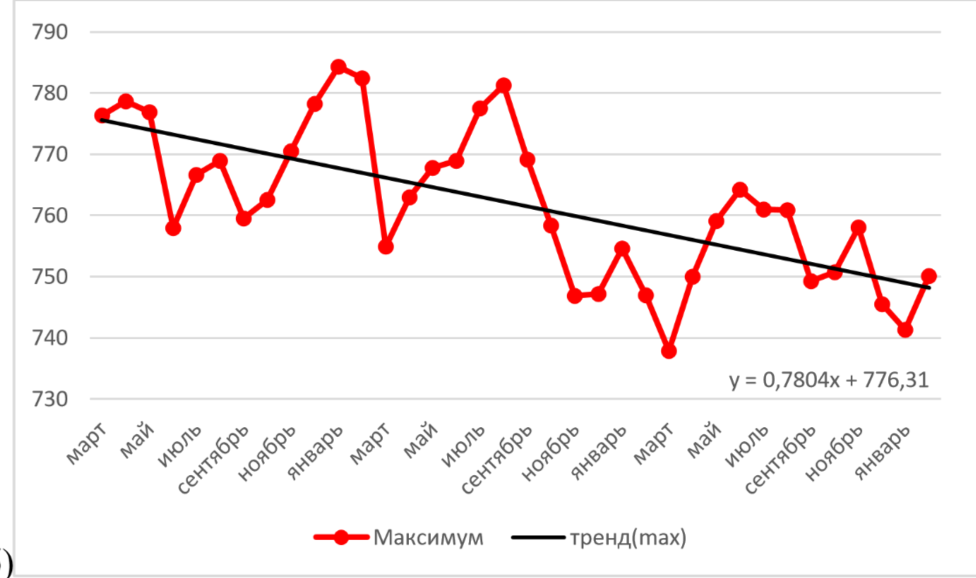
	Average (mm.Hg)	RMS	Min (mmHg)	Max (mm.Hg)
		2018-2019		
March	761.1	10.1	747,	776,
April	776.1	2.4	772,	778,
May	771.1	6.1	758,	776,
June	750.3	4.5	744,	757,
July	762.2	4.1	754,	766,
August	763.6	8.1	738,	768,
September	751.3	5.5	738,	759,
October	758.0	2.5	754,	762,
November	765.6	3.0	760,	770,
December	771.9	3.8	766,	778,
January	782.2	1.6	778,	784,
February	762.6	14.9	741,	782,
		2020-2021		
March	753.3	0.8	751,	754,
April	750.8	5.7	743,	763,
May	762.8	4.4	755,	767,
June	764.4	4.4	754,	768,

July	774.1	2.6	768,	777,
August	774.6	5.3	764,	781,
September	763.1	4.3	757,	769,
October	752.3	5.1	745,	758,
November	743.8	2.1	740,	746,
December	741.0	5.3	731,	747,
January	744.9	6.5	732,	754,
February	738.0	4.7	729,	747,
		2022-2023		
March	735.9	1.8	732,	737,
	Average (mm.Hg)	RMS	Min (mmHg)	Max (mm.Hg)
April	747.0	3.1	738,	750,
May	755.9	2.0	751,	759,
June	760.6	3.1	755,	764,
July	758.6	2.1	754,	761,
August	752.9	7.2	741,	760,
September	747.4	1.7	742,	749,
October	743.4	6.7	733,	750,
November	750.2	5.9	738,	758,
December	733.6	7.2	723,	745,
January	730.2	5.6	723,	741,
February	742.2	4.5	732,	750,

Let us graphically present the minimum, maximum and average values of atmospheric air pressure at the Vise Island station and draw a trend line (Figure 7 a, b, c).



a)



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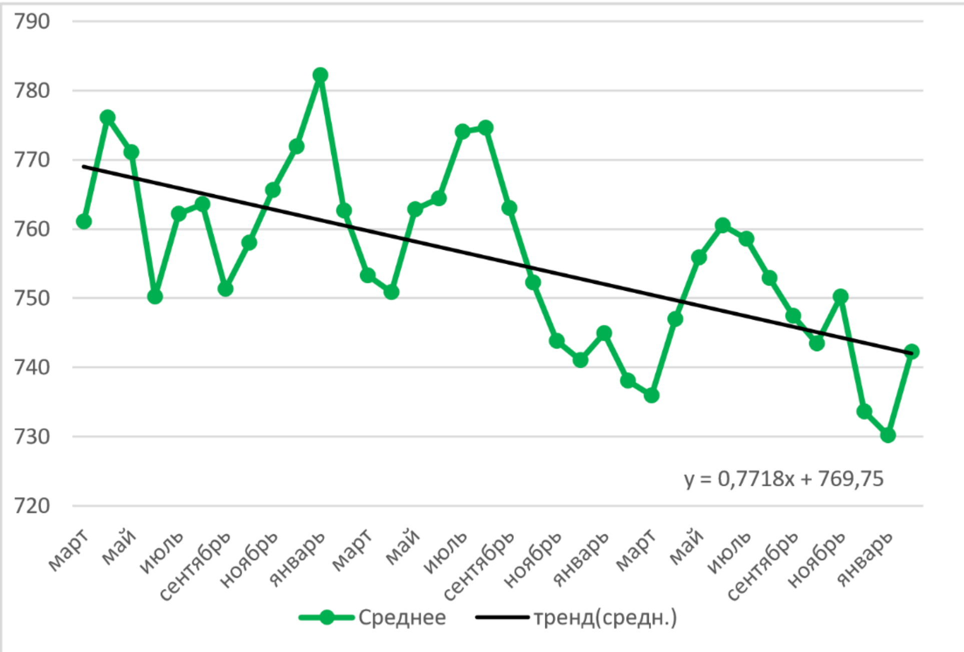


в)

Figure 7. Minimum, maximum and average values of atmospheric pressure at the Vise Island station.

Having analyzed the data obtained, we can conclude that the lowest pressure at the Vise Island station for the entire study period is 723 mmHg. observed in December 2021 The highest pressure was recorded in January 2023. and amounted to 784 mmHg.

The slope of the trend line, in all cases, is quite large and significantly affects the variability of the original series. For minimum values it is 35.3°, for maximum 37.9°, and for average 37.6°. It is also worth noting that every year the values of atmospheric pressure decreased, which is very clearly visible in the graphs.

Table 6. Data on the amount of precipitation (mm.) for each month of the period under consideration at the Valkarkai station.

	2018-2019	2020-2021	2022-2023
March	2.3	4.3	14.5
April	1.8	1	4.4

May	0.5	3.1	4.7
June	12.6	0.9	18.5
July	10.9	14.7	50.5
August	11.3	8.8	35.5
September	25.5	9.6	29.8
October	35.4	13	10.8
November	20	22.2	5.1
December	27.1	2.1	10.3
January	6.6	8.4	10.4
February	24.1	11.2	5.1
In a year	178.1	99.3	199.6

Figure 8 graphically shows the amount of precipitation for each month in the period from 2018-2023.

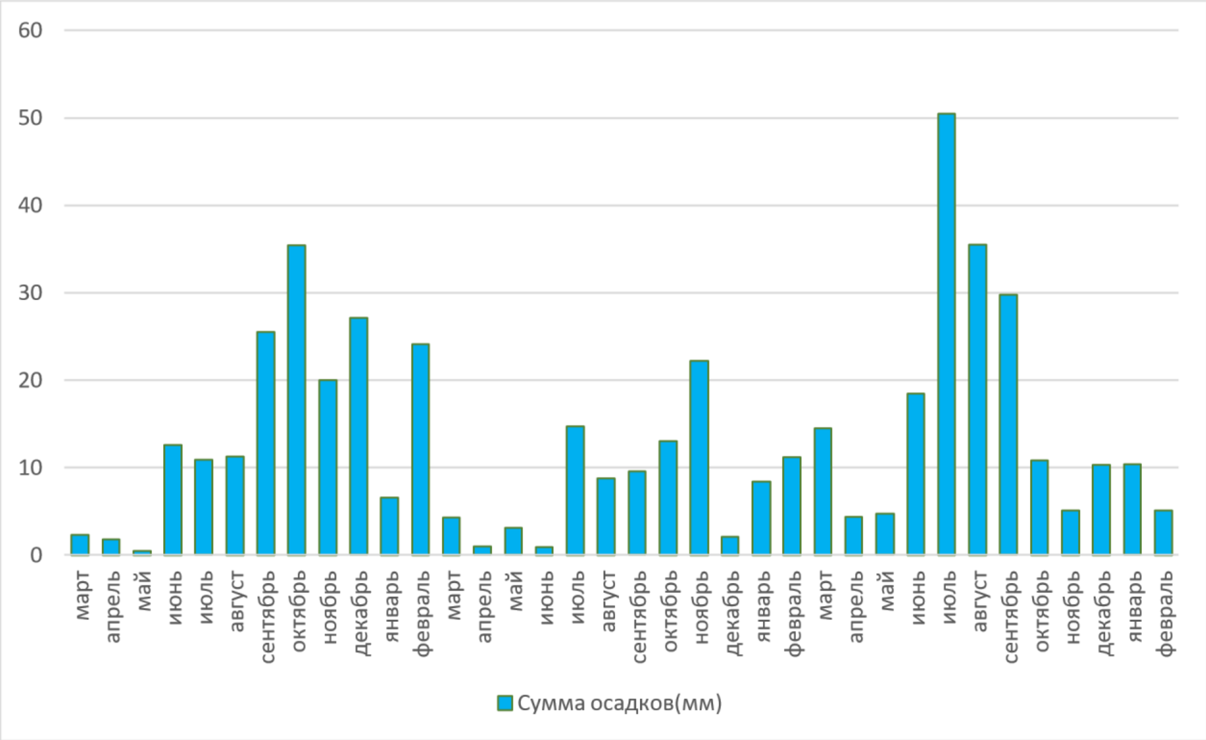


Figure 8. Total precipitation at Valkarkai station for each month.

The lowest level of precipitation at Valkarkay station was observed in May 2019 and amounted to only 0.5 mm. per month. The highest level of precipitation was in July 2022; for the month the amount of precipitation was 50.5 mm.

Having carried out the analysis, we can say that the driest months for the entire study period are April-May, the amount of precipitation during this period of time does not exceed 4.7 mm. The greatest amount of precipitation falls mainly in September-October. The driest period was 2021-2022, with 99.3 mm of precipitation per year.

Table 7. Data on the amount of precipitation (mm.) for each month of the period under consideration at the Vise Island station.

	2018-2019	2020-2021	2022-2023
March	11.6	5	16.5
April	11.3	11.4	9.3
May	11.1	10.6	11.8

June	13.1	8	31.5
July	14.2	43.3	18.2
August	108.9	26.9	31.4
September	18.8	34.8	63.7
October	23.2	29.3	124.3
November	17.9	25.2	8.9
December	15.6	24.6	27.8
January	23.1	11.7	8.1
February	21	12.6	18.5
In a year	289.8	243.4	370

Figure 9 graphically shows the amount of precipitation for each month in the period from 2018-2023.

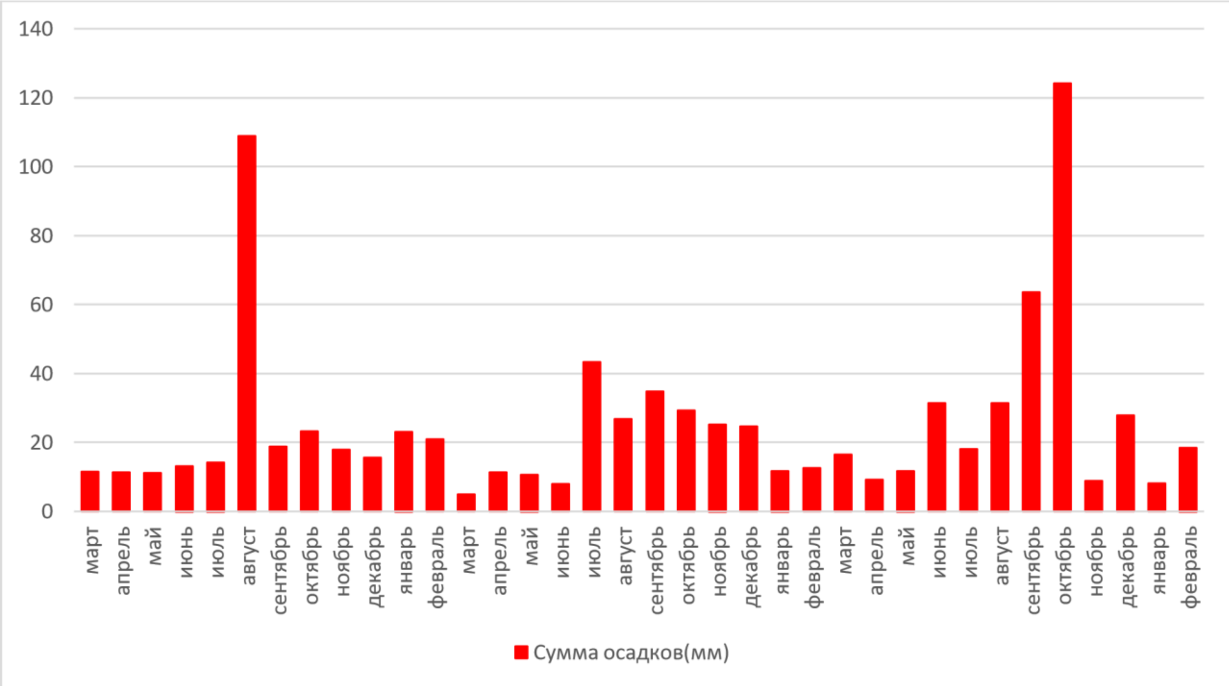


Figure 9. Total precipitation at Wiese Island station for each month.

The lowest level of precipitation at the Vize Island station was observed in March 2018 and amounted to 5 mm. per month. The highest level of precipitation was in October 2022; for the month the amount of precipitation was 124.3 mm. Having carried out the analysis, we can say that the driest months at the Vise Island station for the entire study period are April-May, the amount of precipitation during this period of time does not exceed 11.8 mm. The greatest amount of precipitation falls mainly in August-October. The driest period was 2020-2021, with 243.4 mm of precipitation per year.

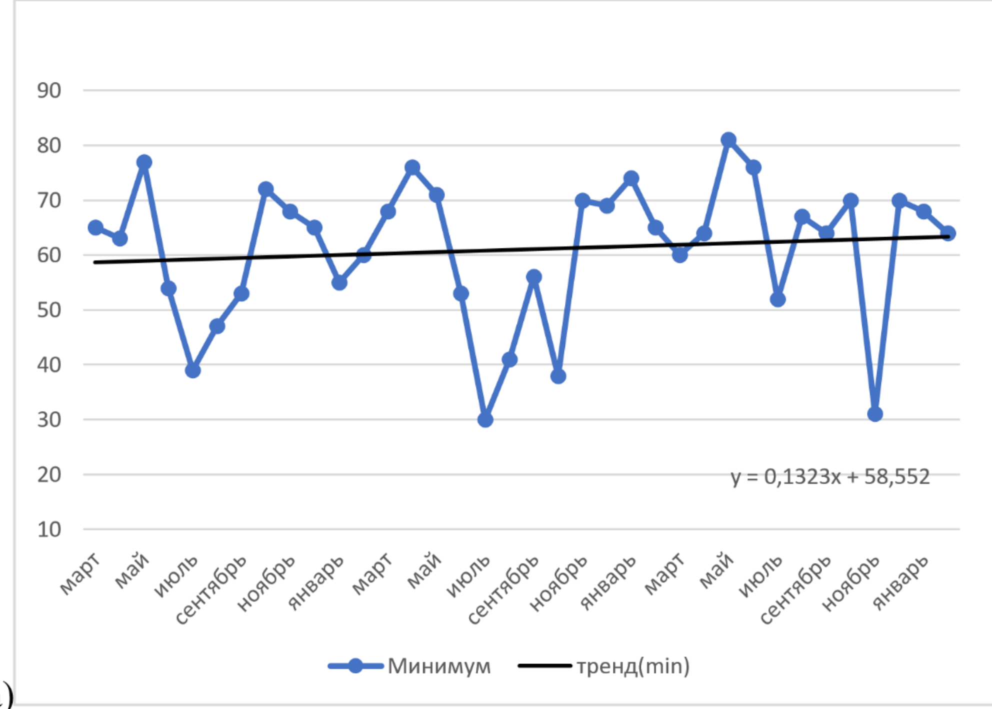
In Table 8, calculated data on relative humidity - maximum, minimum, average monthly humidity and standard deviation for each month of the period under consideration at the Valkarkay station.

Table 8. Average monthly relative humidity values at Valkarkai station.

	Average %	RMS	Min%	Max %
		2018-2019		
March	87	8.6	65	95
April	87	8.4	63	95
May	92	5.4	77	100
June	90	10.5	54	100
July	81	14.9	39	100

August	81	16.3	47	100
September	84	10.1	53	97
October	88	7.4	72	100
November	88	6.8	68	95
December	86	7.6	65	96
January	83	8.8	55	95
February	88	7.8	60	100
		2020-2021		
March	80	6.9	68	91
April	89	5.4	76	95
May	90	7.6	71	100
June	91	12.3	53	100
July	84	16.4	30	100
August	90	16.5	41	100
September	86	14.4	56	100
	Average %	RMS	Min%	Max %
October	86	13.1	38	100
November	85	6.8	70	95
December	79	7.5	69	93
January	82	4.6	74	90
February	80	6.4	65	90
		2022-2023		
March	78	6.8	60	95
April	84	6.6	64	95
May	92	4.1	81	100
June	92	6.9	76	100
July	90	11.6	52	100
August	96	6.8	67	100
September	91	9.1	64	100
October	87	7.1	70	98
November	83	13.8	31	100
December	84	7.2	70	97
January	78	6.6	68	96
February	73	7.4	64	90

Let us graphically present the minimum, maximum and average values of air humidity at the Valkarkai station and draw a trend line (Figure 10 a, b, c).



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20
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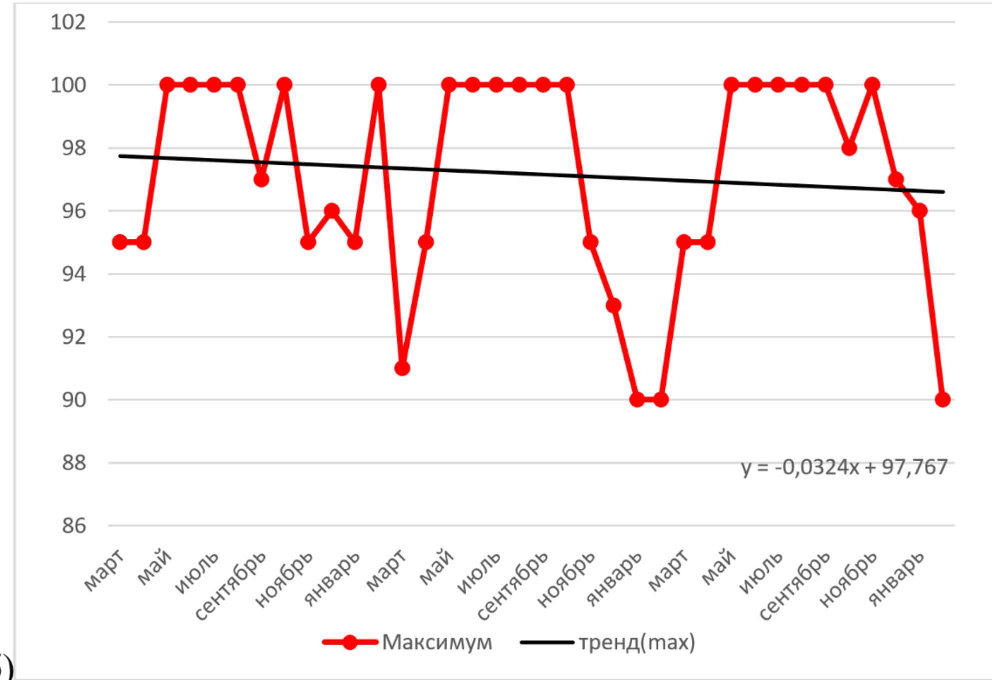

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86
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ноябрь
январь
март
май
июль
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Максимум
тренд(max)

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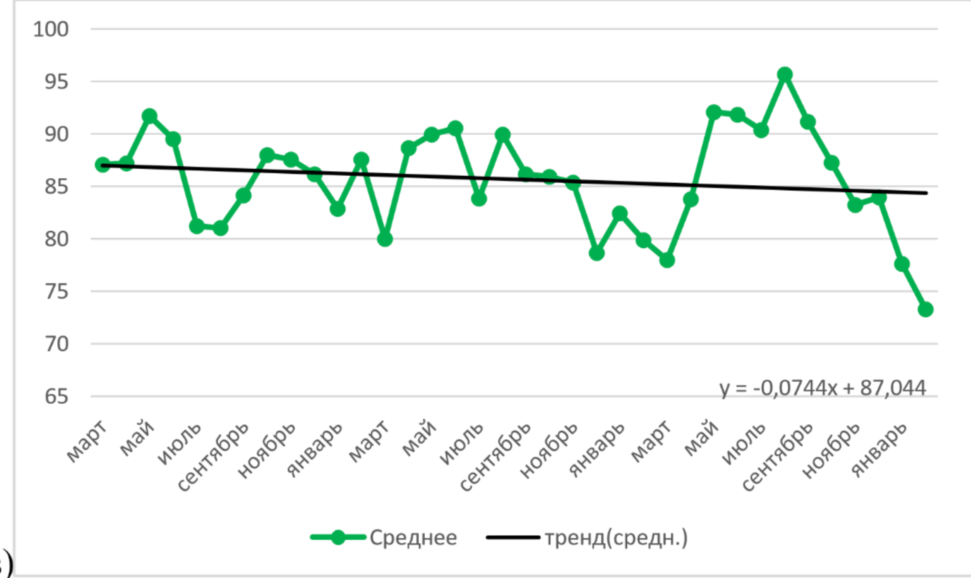


в)

Figure 10. Minimum, maximum and average humidity values at Valkarkai station (%).

Having analyzed the data obtained, we can conclude that the lowest humidity value at Valkarkai station for the entire study period - 31% was observed in November 2019. 100% humidity in this region is observed mainly in the summer months. The slope of the trend line for minimum values is 7.54°, for maximum values 1.84°, and for average values 4.25°. Consequently, the maximum significant trend lines do not make any contribution to the formation of the variability of the original series.

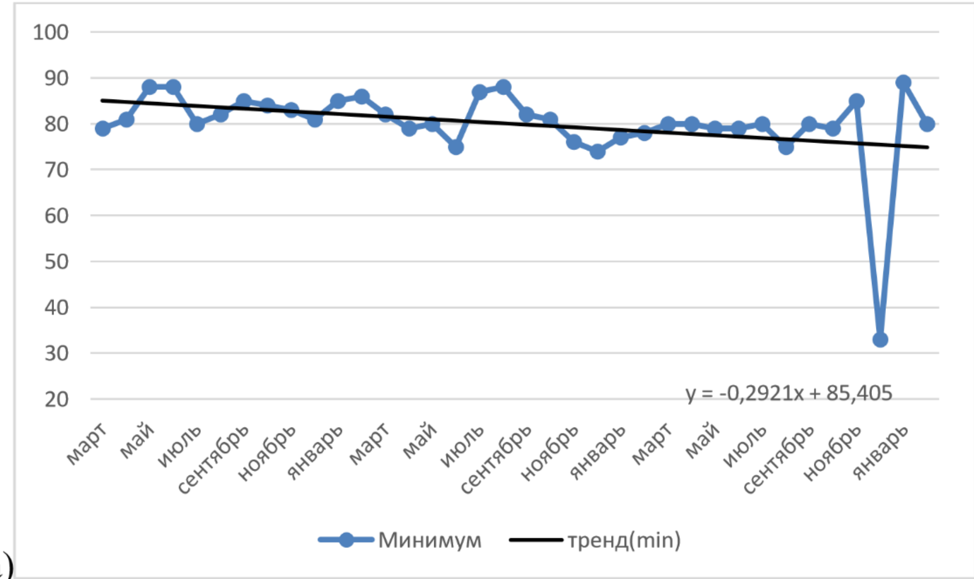
Table 9 contains calculated data on relative humidity - maximum, minimum, average monthly humidity and standard deviation for each month of the period under consideration at the Vise Island station.

Table 9. Average monthly relative humidity values at Wiese Island station.

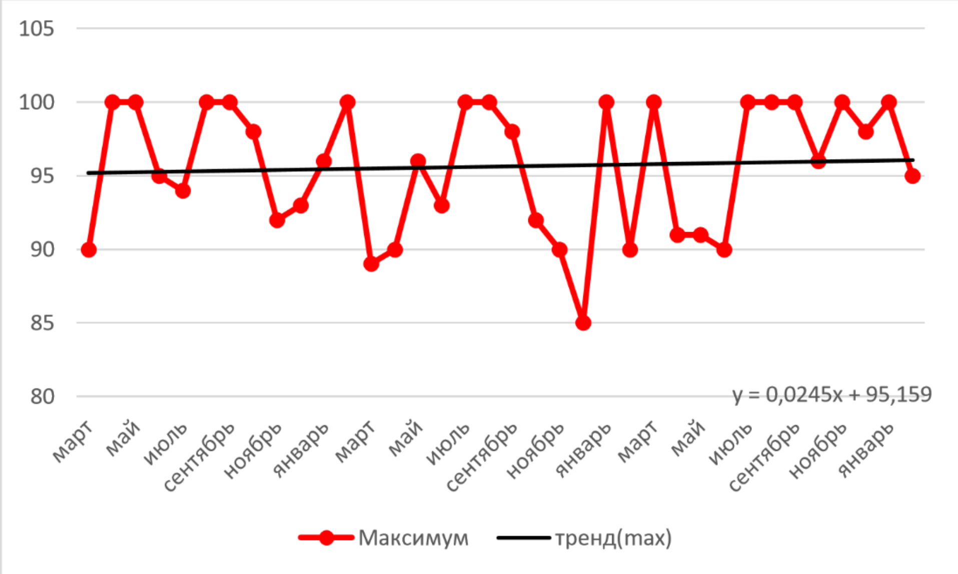
	Average	RMS	Min (%)	Max (%)
		2018-2019		
March	84	3.4	79	90
April	89	7.0	81	100
May	96	3.9	88	100
June	92	2.4	88	95
July	86	4.0	80	94
August	88	4.3	82	100
September	97	3.7	85	100
October	93	3.3	84	98
November	88	3.0	83	92
December	87	3.6	81	93
January	90	3.8	85	96
February	96	4.0	86	100
		2020-2021		
March	85	2.4	82	89
April	85	3.3	79	90
May	86	4.8	80	96
June	83	5.6	75	93
July	92	4.3	87	100
August	95	3.2	88	100
September	90	5.1	82	98
October	85	3.3	81	92
November	80	4.7	76	90

December	80	3.5	74	85
January	86	6.3	77	100
February	84	3.2	78	90
		2022-2023		
March	92	5.6	80	100
April	87	3.1	80	91
May	86	3.2	79	91
June	83	3.2	79	90
July	94	4.9	80	100
August	86	5.1	75	100
September	87	6.1	80	100
October	87	5.6	79	96
November	92	4.7	85	100
December	91	11.7	33	98
January	94	3.5	89	100
February	91	4.0	80	95

Let us graphically present the minimum, maximum and average values of air humidity at the Vise Island station and draw a trend line (Figure 11 a, b, c).



a)



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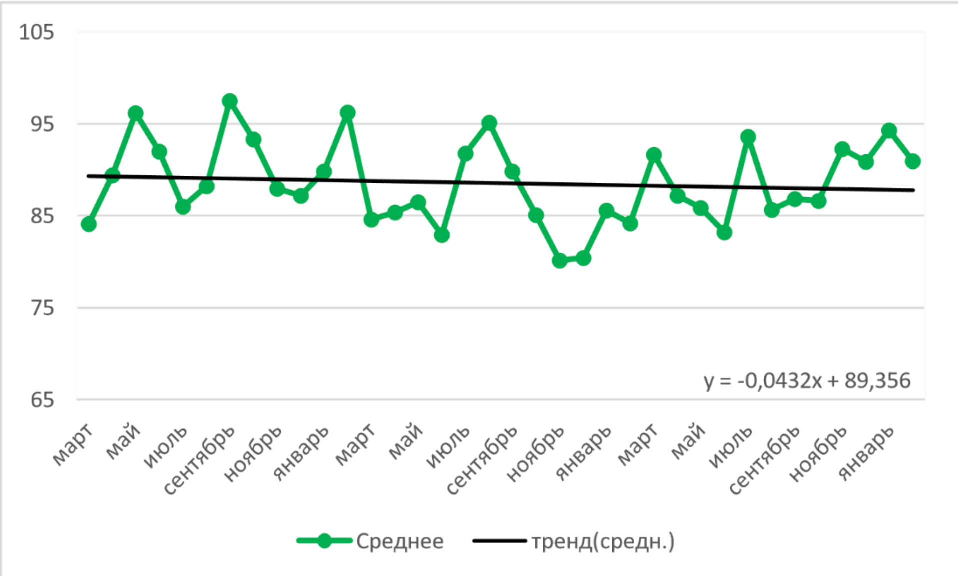


в)

Figure 11. Minimum, maximum and average humidity values at Vise Island station (%).

Having analyzed the data obtained, we can conclude that the lowest humidity value at the Vise Island station for the entire study period - 33% was observed in December 2019. 100% humidity in this region is observed almost every season. The slope of the trend line for minimum values is 16.2°, for maximum values 1.4°, and for average values 2.47°. Consequently, the trend line of maximum values does not make any contribution to the formation of the variability of the original series.

Table 10. Maximum wind speeds at Valkarkay station in the period from 2018-2023.

	2018-2019	2020-2021	2022-2023
March	19	10	12
April	10	11	9
May	10	10	13
June	12	12	12
July	12	10	12
August	11	12	10
September	10	11	13

October	15	12	14
november	21	7	20
December	13	13	14
January	16	12	12
February	13	19	16

According to Table 10, the highest wind speed was recorded in November 2019 and amounted to 21 m/s.

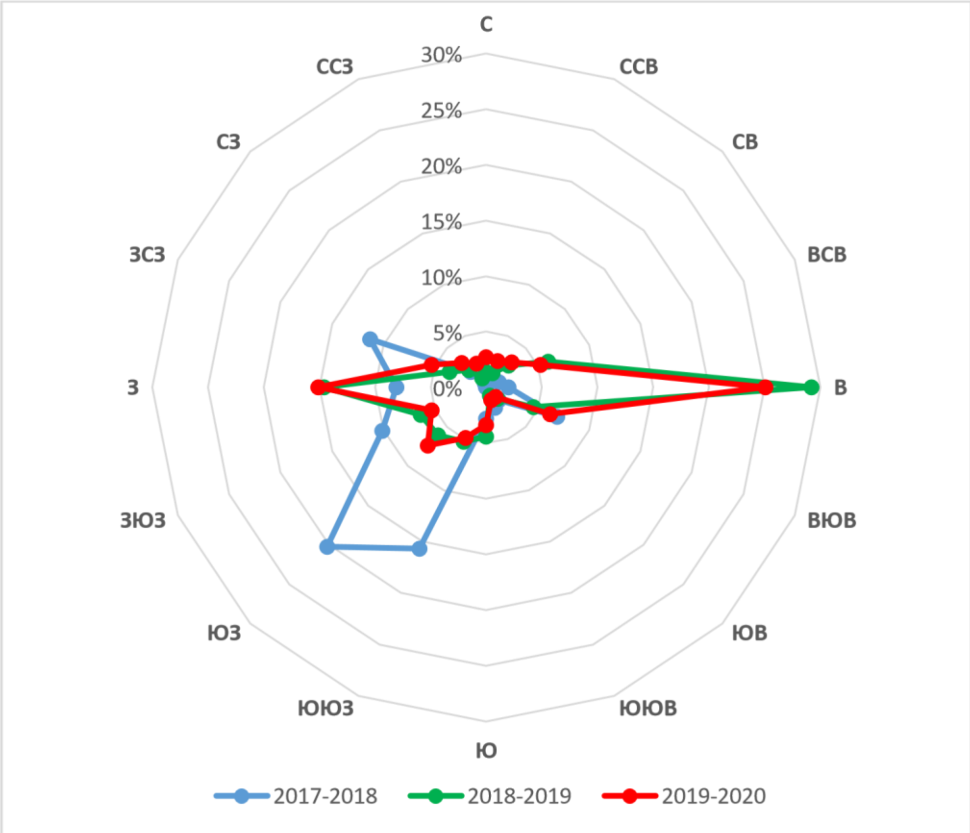


Figure 12. Distribution of wind directions by year at Valkarkai station.

Having analyzed the wind rose, we can conclude that in the period from 2018 to 2019. winds were predominantly observed in a southwesterly direction, their share amounted to 20%. The diagram shows that in the period from 2018-2023. At the Valkarkay station, winds from the east were predominantly observed, their share in 2019-2021. amounted to 25%, and from 2022-2023. 29%. It is also worth noting that there are practically no winds from the north, their share does not exceed 2.7%.

Table 11. Maximum wind speeds in m/s at the Vise Island station in the period from 2018-2022.

	2018-2019	2020-2021	2022-2023
March	12	13	12
April	14	11	10
May	11	11	10
June	15	15	13
July	10	16	12
August	13	11	1
September	15	14	12
October	14	12	12

November	11	16	12
December	15	15	15
January	12	12	13
February	12	16	17

According to the table, the highest wind speed was recorded in February 2020 and amounted to 17 m/s.

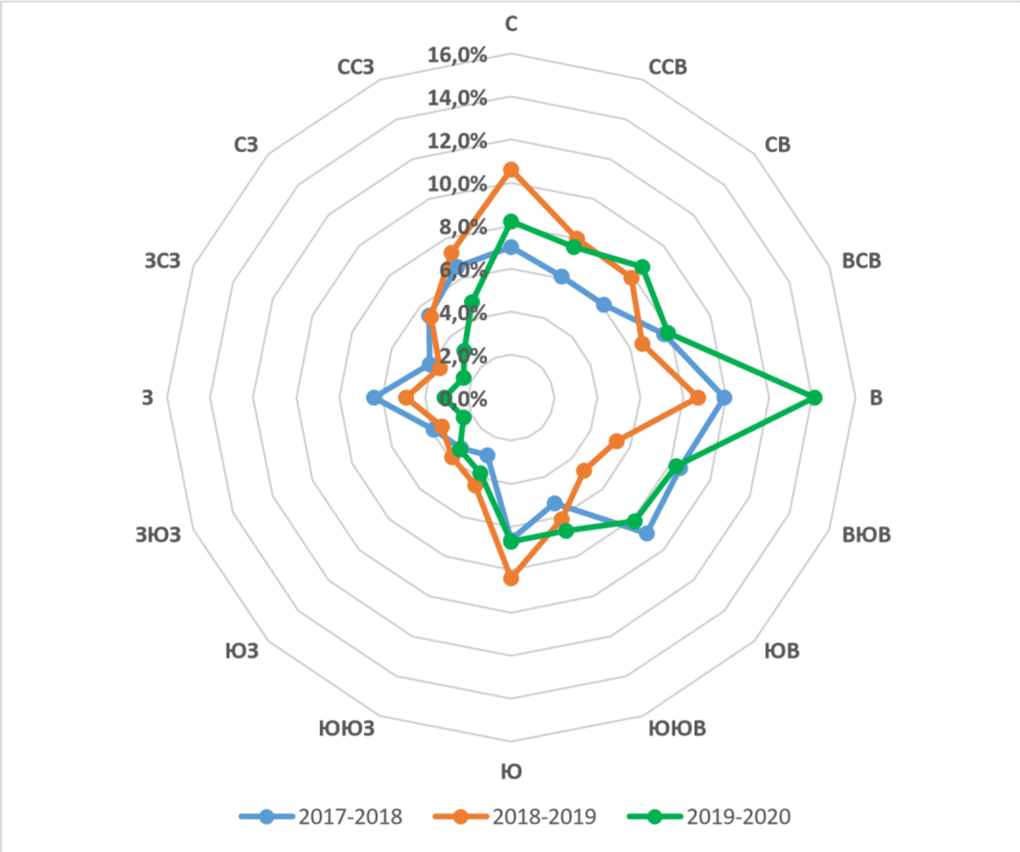
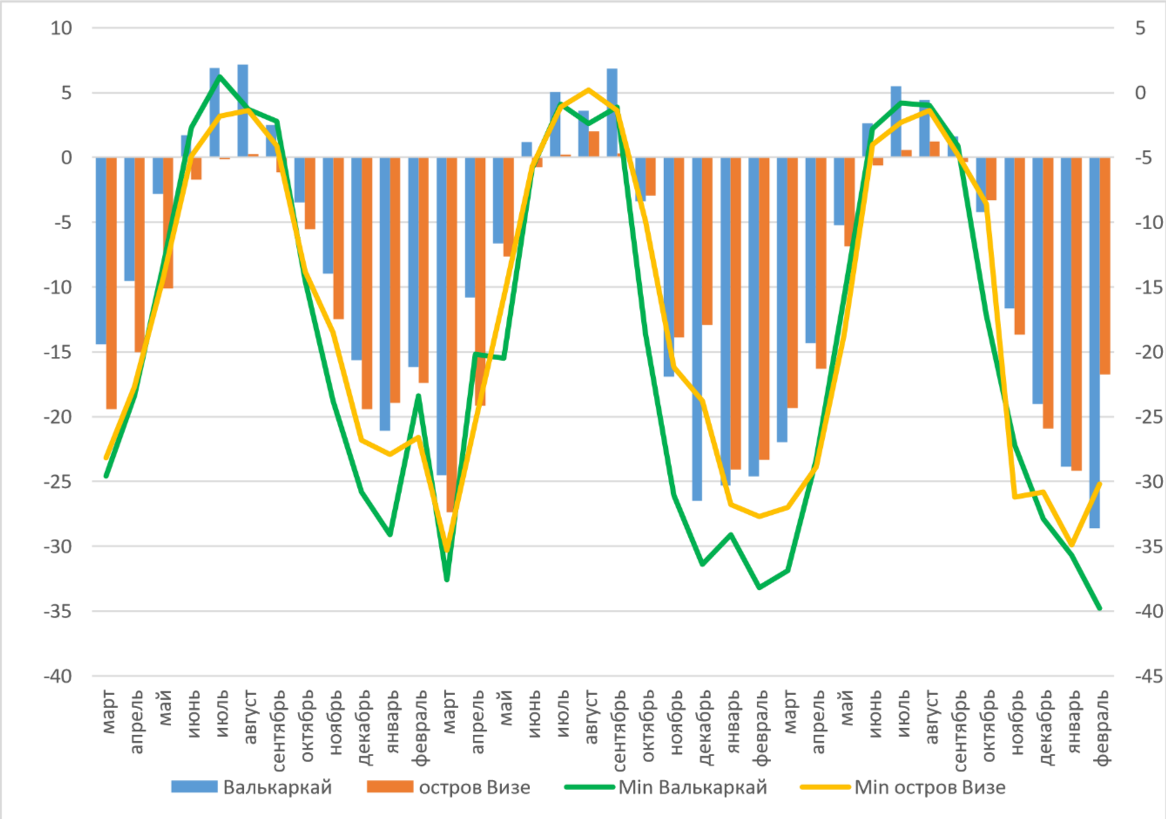
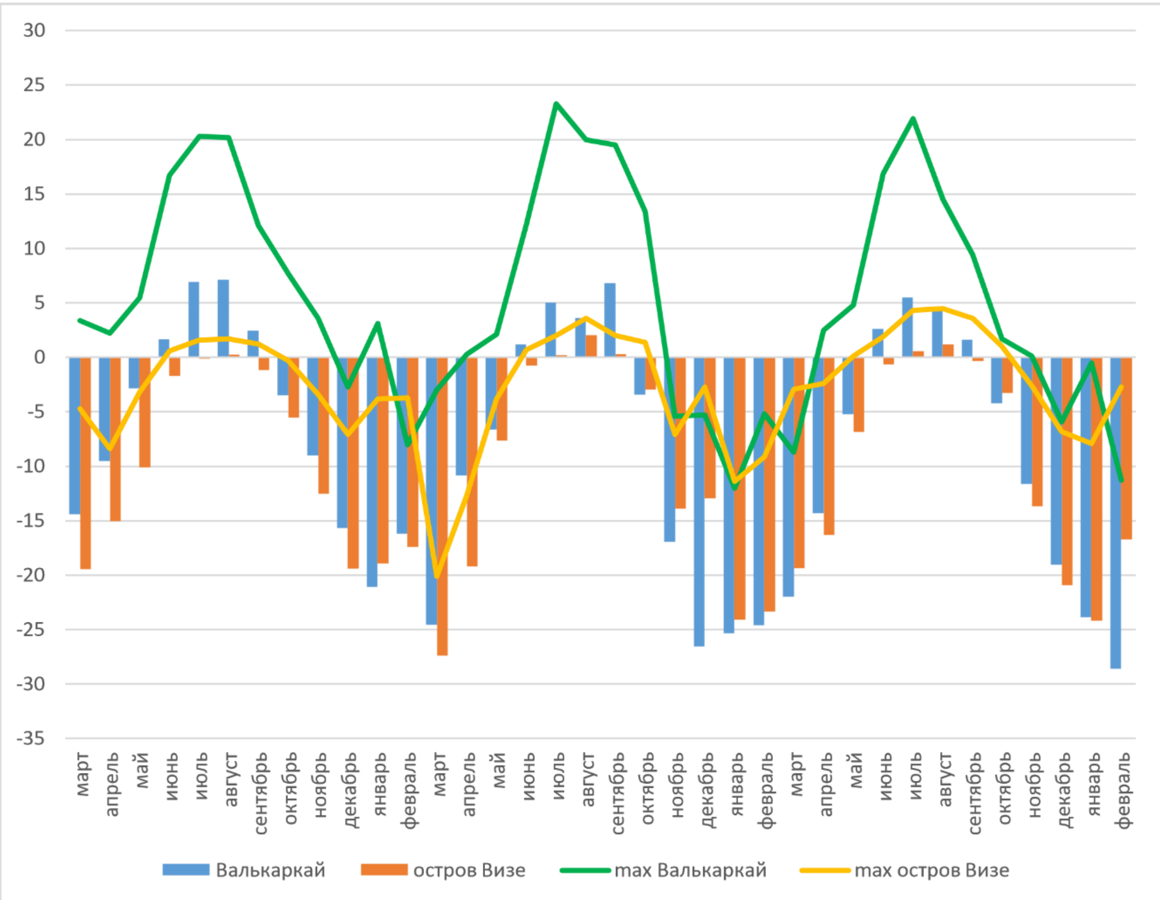


Figure 13. Distribution of wind directions by year at the Vise Island station.

After analyzing the wind rose, we can conclude that the wind directions at the Vise Island station are distributed quite evenly, but still, over the entire period under study, winds in the eastern direction mainly predominate. Winds from southwestern directions blow the least in this region, their share does not exceed 4.4%. We examine the results of air temperature obtained at the stations of Valkarkay and the island of Vize in the period from 2018. until 2023 Figure 14 (a, b) shows how average monthly temperatures, maximum and minimum temperatures change between two stations over the entire study period, by month.



a)



b)

Figure 14. Graph of changes in average, maximum and minimum temperatures between two stations.

Considering the average monthly temperature values at two stations simultaneously, we can say that the lowest temperatures occur in January-March. The greatest range of values occurs in the summer months. On the island of Vize, the maximum temperature in the summer season did not exceed +3.6°C, when at the Valkarkai station the maximum temperature in July every year reached +20°C and above (the maximum temperature at Valkarkai for this period was recorded in July 2019 was +23,3°C).

It is worth noting that the average monthly temperatures at the Valkarkai station and the Vise Island station are quite close in value, this is confirmed by the calculation of the correlation coefficient which is equal to 0.96.

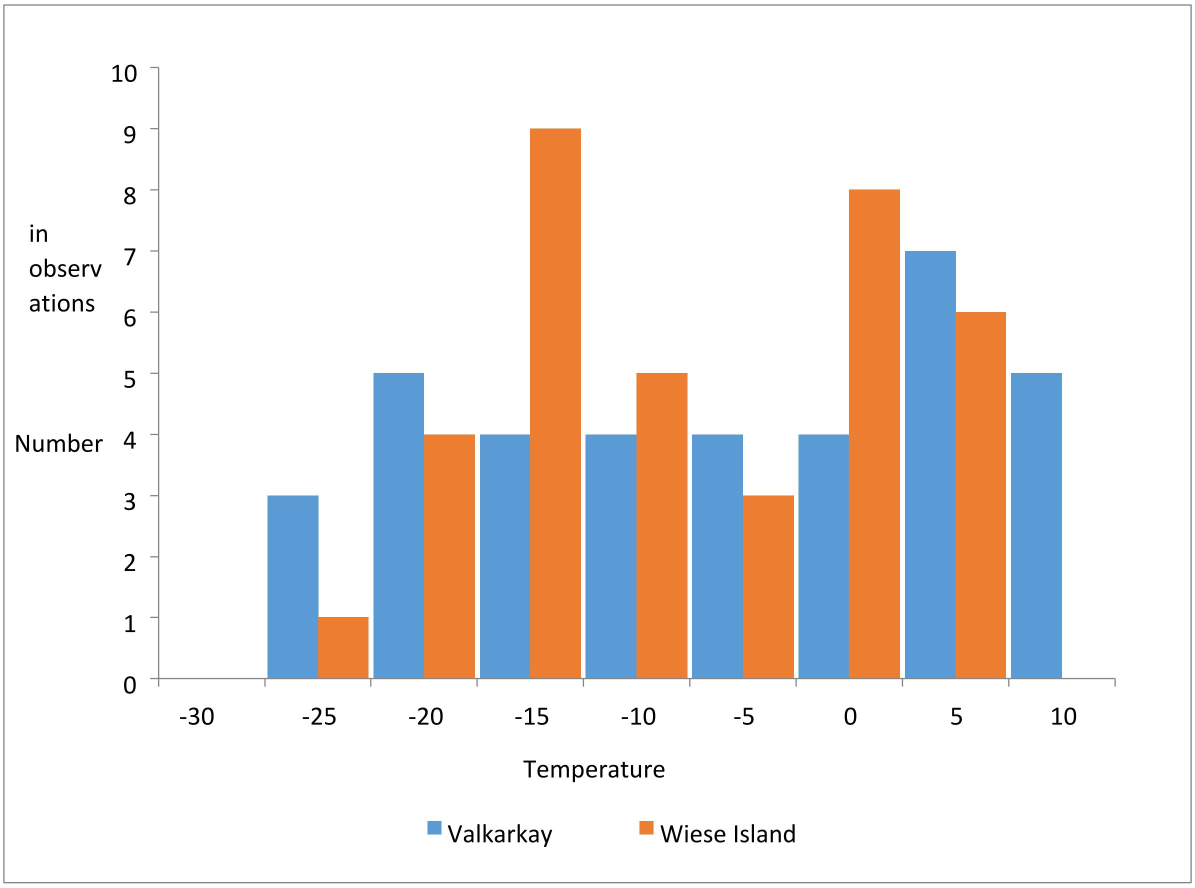


Figure 15. Distribution of average monthly temperatures at two stations.

From the above graphs it can be seen that at the Valkarkay station the largest number of average monthly temperature values fall in the range from 0°C to 10°C, at the Vise Island station from -10°C to -20°C. In general, the bulk of average monthly temperature values at Valkarkay station fall in the range from 0°C to -15°C. And on the island of Vize the average monthly temperatures are quite unevenly distributed. Let us consider the results of atmospheric air pressure obtained at the Valkarkai and Vize Island stations in the period from 2018 to 2023. Figure 16 shows how atmospheric pressure changes between two stations over the entire study period, by month.

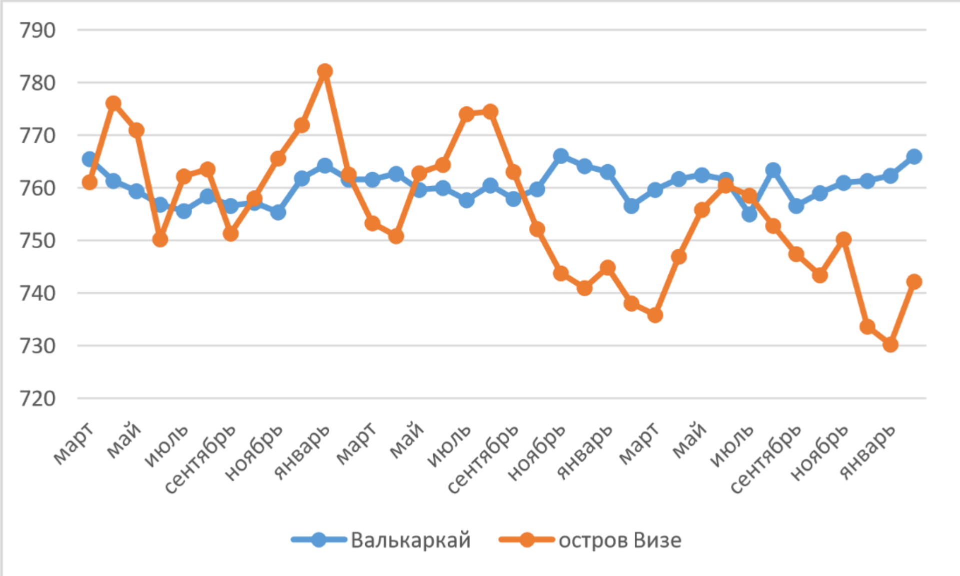


Figure 16. Graph of changes in atmospheric pressure between two stations (mmHg).

Having analyzed the graph, we can say that at the Valkarkai station the atmospheric pressure values are more uniform and do not fall below 750 mmHg. and do not exceed 770 mm Hg. this indicates that the pressure in this region is within normal limits. At the Vise Island station, throughout the entire study period, large fluctuations in average monthly atmospheric pressure values are visible. It is also worth noting that starting from mid-2019, pressure has been trending downward. The nature of the variability of atmospheric pressure at the Valkarkay station and the island of Vize is very different, this is also indicated by the calculation of the correlation coefficient, which is equal to -0.13, this determines the presence of an opposite connection. A comparison of precipitation data is shown in Figure 17.

Figure 18 shows data from two stations on the amount of precipitation for each month from 2018 to 2023.

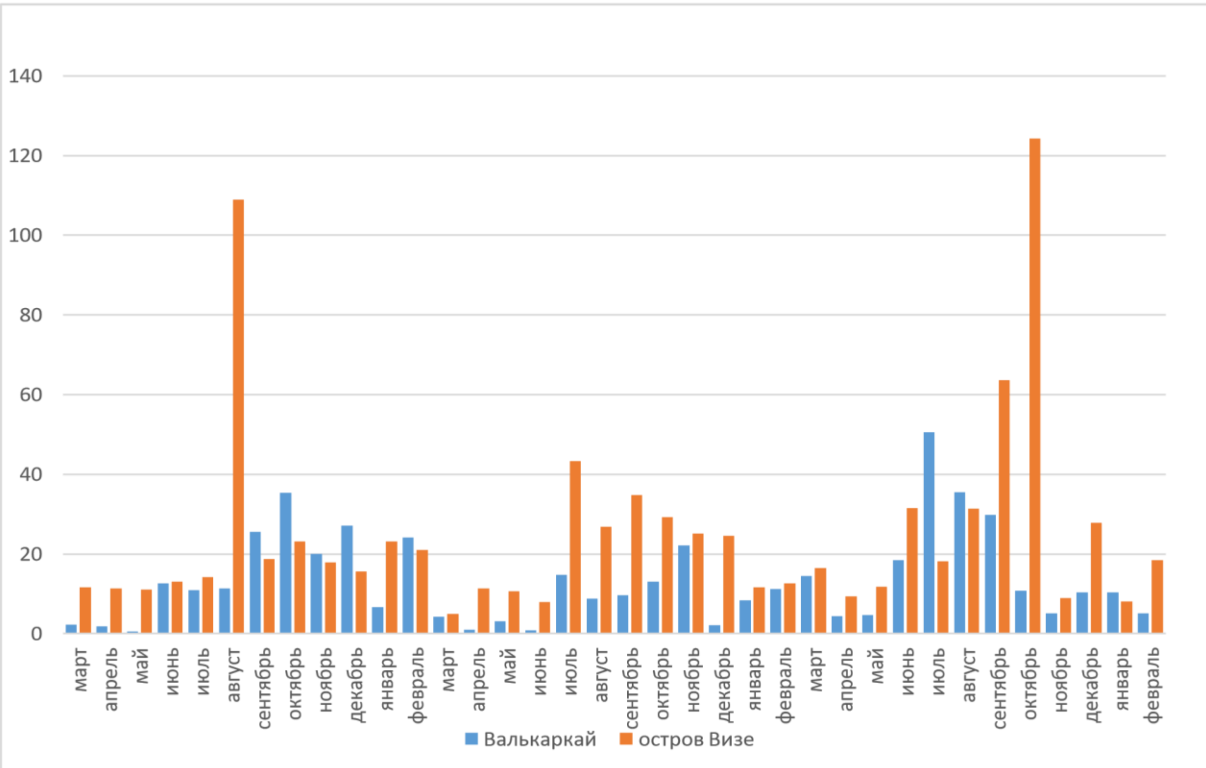


Figure 17. Total precipitation for each month at two stations.

The graph shows that at two stations the greatest amount of precipitation falls in the summer and autumn seasons. On the island of Vize, precipitation is more abundant, the maximum level reached 124.3 mm, the minimum level of precipitation for each month did not fall below 5 mm, when at the Valkarkai station in the spring months the precipitation level does not exceed 4.7 mm.

Two stations have fairly low precipitation levels, but Valkarkai station has a more evenly distributed average monthly precipitation and a drier climate. The correlation coefficient between stations is 0.13, the relationship between the indicators is very weak.

A comparison of relative humidity data is shown in Figure 18.

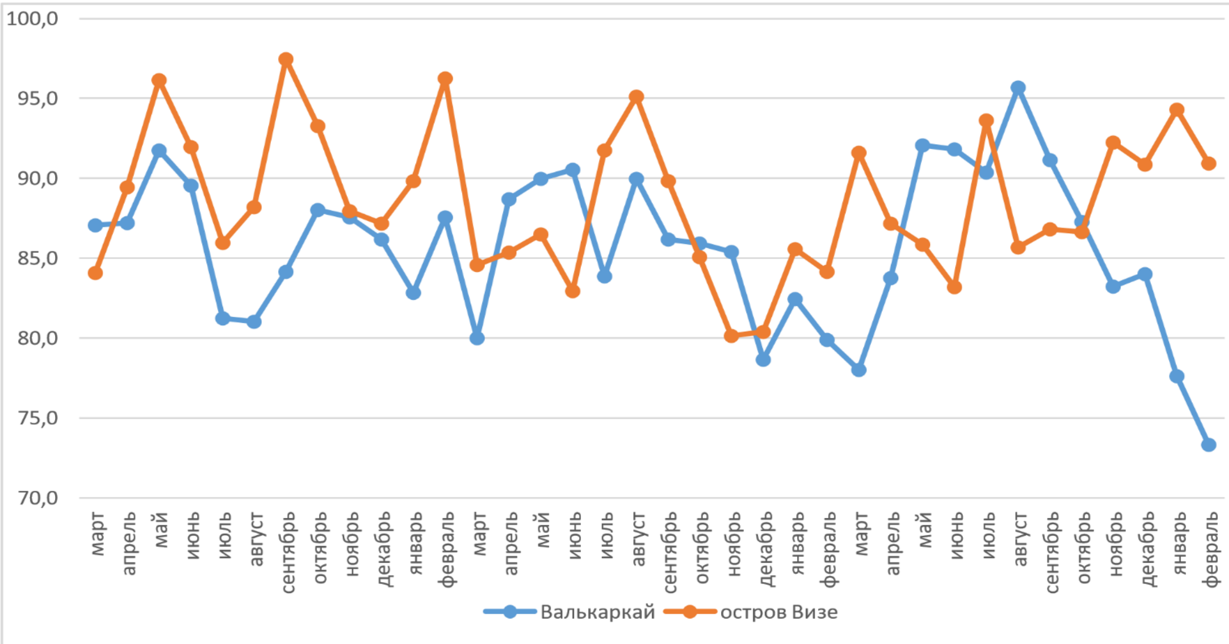


Figure 18. Data from two stations on relative humidity for each month from 2018 to 2023.

The graph shows that at Valkarkai station the humidity for the entire period was only in August 2019. exceeded 95%; in other months it did not exceed 92%. The humidity on the island of Vize is higher, this is due to the conditions of the marine climate. The correlation coefficient between stations is negative and equal to -0.01.

Wind data comparison

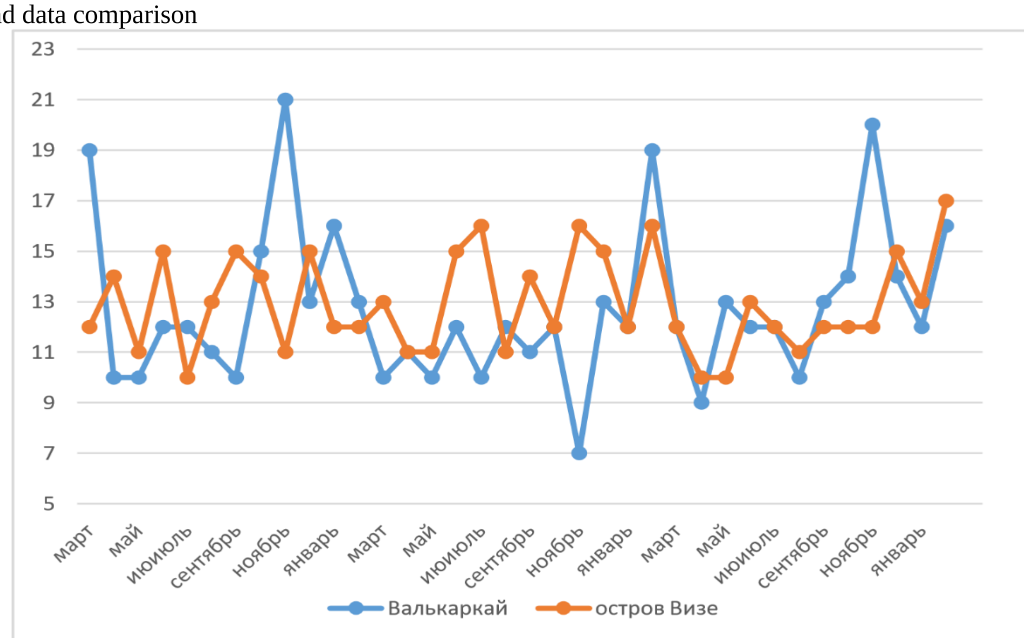


Figure 19. Maximum wind speeds at two stations in the period from 2018 to 2023.

From the graph data, it is clear that the maximum speeds at the Valkarkai station reach 21 m/s, while on the island of Vize the maximum speed does not exceed 17 m/s. The relationship between wind speeds between stations is insignificant, which is confirmed by a very weak correlation, the coefficient of which is 0.005.

It is also worth noting that at the Valkarkai station, winds in the eastern direction mainly predominate, and winds in the northern directions are observed very rarely, their share is only 4% for the entire observation period. On the island of Vize, wind directions are more evenly distributed, but still more easterly directions were observed.

Conclusion

In the process of globalization, large-scale changes are taking place in the economic activities and lifestyle of the indigenous inhabitants of the Arctic. Today, Aboriginal people choose different development strategies, but for most of them, industrial development has become the most important factor in modern life. The activities of enterprises bring huge amounts of money to regional budgets, part of which goes to finance targeted development programs for indigenous peoples of the North, to help the agro-industrial complex, to support indigenous communities, and to compensate for losses caused during the development of territories. Overall, this has a positive impact on the well-being of indigenous and local populations. Modern infrastructure is developing in the Arctic: roads are being built, modern means of communication and energy are being used, residential buildings and social and cultural facilities are being built. This creates conditions so that indigenous peoples do not feel outside the “benefits of civilization” and receive comparable access to education, medical care and culture as residents of other regions of Russia. The process of interaction between indigenous peoples and mining companies is regulated by federal and regional laws. In addition, the districts have developed the practice of concluding agreements and agreements between communities and industrial enterprises. Of particular note is the unique experience of the Yamal-Nenets Autonomous Okrug in the creation of an Ethno-Ecological Council, whose tasks include making proposals to local governments to improve the legal framework in the field of regulation of land legal relations, environmental protection, environmental management and subsoil use. It is advisable to apply this experience in other regions. The policies of industrial companies in the North of Russia have been gradually changing for the better in recent years. Their managers and employees come to the realization that they are not pioneers of the northern and Arctic territories, that their activities must not only be carried out within the framework of the legal, primarily environmental, field, but also comply with moral standards. And since industrial development of the Arctic began before the adoption of modern environmental and socially oriented legal standards, companies should use compensatory measures and actively cooperate with local and indigenous populations in the areas of their operations. The management of many enterprises is aware of their responsibility and adopts documents and regulations that define the principles of activity and rules of behavior of employees, especially in places of traditional residence and traditional economic activities of indigenous peoples. Against the background of the material well-being of the visiting population employed in the mining industry, the social problems of the aborigines are especially visible. In addition to the fact that the level of wages in fishing, reindeer husbandry, and marine hunting is an order of magnitude lower than in industry, The high level of unemployment among indigenous peoples poses a serious threat to social stability. As a rule, industrial enterprises refuse to hire indigenous people due to low qualifications, and there are no reserves for increasing employment in traditional industries. In the reindeer herding industry of the Yamal-Nenets Autonomous Okrug there is even a problem of “oversupply” of deer and shepherds, aggravated by the depletion of food resources. In Chukotka reindeer husbandry, there are other concerns - a shortage of reindeer herders and livestock workers; the desired increase in livestock is not happening, and therefore, the scope of employment is not expanding. The authorities associate the prospects for reducing unemployment and developing the traditional sector of the economy of the North with the development of communities and processing of products from traditional sectors of the economy. Traditional forms of economic management of the Arctic peoples are increasingly involved in the regional economy, and ethnocultural heritage is recognized as an important resource for the vitality of society, which not only needs to be preserved, but also modern forms of working with it must be found. Particular attention in our study is paid to the education of indigenous peoples of the North as the most important mechanism of adaptation. In the educational process, the educational potential of the basic means of the ethnic culture of the northern peoples is widely used (oral folk art, arts and crafts, folk games and toys, traditional physical competitions, festive and gaming folklore). It is probably worth considering the possibility of creating new forms of educational structures that are more adequate to the ethnic needs of northerners, as well as paying more attention to the targeted training of pedagogical specialists in the field of ethnocultural traditions of education. In the context of increasing industrial development, today there is an obvious lack of resources for traditional environmental management. The reduction of pastures and the pollution of water bodies lead to the need to search for new ways of social adaptation in the context of the curtailment of traditional forms of management. Many Aboriginal families see a solution in young people receiving vocational education and specialties that are in demand in the labor market. At the same time, many experts express thoughts about the need for more flexible forms - perhaps nomadic, primarily primary - education for children of reindeer herders in order to mitigate the stress that is inevitable for younger schoolchildren when parting with their parents and during the first years of life and study in boarding school It is also important to understand that further development of traditional sectors of the economy is impossible without a sufficient number of Aboriginal people who have received both basic and professional special education. Today you need not only to herd deer, fish, hunt animals, but also have knowledge of management, marketing, accounting, and be economically and legally literate. So far in the North there are very few such specialists among indigenous peoples. After all, one of the reasons that communities cannot develop successfully is associated with financial reporting issues. A useful measure could be closer interaction between industrial companies and educational institutions in cities, schools and boarding schools. Familiarity and constant communication between the indigenous and visiting populations are of great importance. Their rapprochement would contribute to the establishment of a favorable psychological climate and would help graduates of boarding schools find their place in the future, including in industrial enterprises. In Russia and the world there are examples of successful participation of industrial companies in educational programs for indigenous and local populations in the Arctic and training programs for activists of indigenous social movements, which would be useful to be widely covered in the media. Measures of targeted government support for the development of indigenous peoples in combination with assistance to various forms of their self-organization are necessary. Such a policy of interested federal and regional authorities could guarantee movement towards limiting state paternalism, forming partnerships and mastering negotiation procedures by all their participants. The monograph proposes legal measures as mechanisms to overcome risks for indigenous peoples of the North associated with the industrial development of areas of their traditional residence and economic activity. Among them are the improvement of legislation, primarily the adoption of a special Federal Law “On assessing the impact on the ancestral habitat and traditional way of life of indigenous peoples of the North, Siberia and the Far East”, introducing changes to land and resource legislation that correspond to the legal rights and interests of indigenous peoples, tightening environmental regulations in the Arctic. To improve the effectiveness of the proposed measures, monitoring of law enforcement practice will be required. It seems to us that in such work, an interdisciplinary approach is especially important, the joint activities of anthropologists, lawyers, ecologists, and possibly the involvement of biogeographers, economists and other specialists. An effective means of improving the quality of life of Aboriginal people could be the development by industrial companies of a policy focused on interaction and dialogue with indigenous peoples, studying and taking into account their interests. A fruitful practice in this regard appears to be the practice of campaigns, recognized in many countries, to accept obligations on social corporate responsibility, based on international standards formulated in the UN Declaration of the Rights of Indigenous Peoples (2007) and the Guiding Principles for Business Development in the Context of Human Rights (2011). Company policies based on these principles should combine direct financial injections into the regions in which they operate with targeted competitive projects aimed at developing communities and families of indigenous peoples, supporting their cultures and languages. In this case, primary importance should be given to the social sphere - education and health care, construction and support of enterprises for processing products of traditional industries. Special measures are needed both in relation to Aboriginal people living in cities and towns with a mixed population, where different economic and cultural structures coexist, and in relation to ethnically homogeneous communities of the indigenous population leading traditional environmental management. The multivariate approach proposed in the book takes into account the ability of people of any culture and social environment to innovate and gives preference to individual strategies of people, their fundamental desire to provide better personal and social living conditions. At the same time, the industrial development of the Arctic zone can contribute to the development of the indigenous peoples of the region if government authorities provide a legal framework and socio-economic guarantees, increase the efficiency and quality of education, realize the right of people to reliable information, which in total will certainly contribute to the formation of a favorable social climate. Only taking into account all these circumstances is it possible for the free, preliminary and conscious participation of indigenous peoples in decision-making that affects their interests, full control over the activities of industrial enterprises, and the application of high standards of social and environmental responsibility to their activities in the Arctic.

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Issue Article

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FEATURES OF RUSSIA'S STRATEGIC INTERESTS IN THE RUSSIAN ARCTIC

***Abstract**: The article discusses the international aspects of problems related to the Arctic, the improvement and updating of strategies and policies in this zone of the European Union and a number of countries (India, USA, Finland, Faroe Islands), withdrawal from projects in the Russian Arctic after the start of a special military operation of a number of large European and Asian multinational companies. It is emphasized that Western states continue to increase their military presence in the region. The situation was greatly complicated by the beginning of the process of Finland and Sweden joining NATO, which strengthens the potential of the alliance and creates real military threats to Russia in the Arctic direction. Using examples of decisions of the Government of the Russian Federation in 2022, the problems of the Russian Arctic, especially related to the development of the Northern Sea Route and some subjects of this zone for the next 15 years, are analyzed. Attention is focused on the nature of the activities of the country's leadership, ministries and departments, legislative bodies, representatives of business and public organizations for the integrated development and exploration of the Arctic in the light of unfavorable international events of 2020–2022. It is noted that the real impact of the NWO on the Arctic region can only be determined by its final results. The article also analyzes the strategic interests of Russia and China in the Arctic. It represents one of the most promising and underdeveloped regions of the world. Russia, as an Arctic state, has its own interests in the northern territories and is implementing policies aimed at strengthening its leading position in their development. China, on the other hand, views its participation in projects for the development of the Arctic as an opportunity to establish stable ties with this region, and here the comprehensive strategic partnership between the Russian Federation and the PRC takes on new shape. In particular, it is economically beneficial for both countries to develop northern sea routes, which will reduce the delivery time for goods from Asia to Europe and vice versa. It is noted that joint Arctic projects make it possible to intensify the development of communications along the Northern Sea Route and ensure the* *environmentally friendly development of natural resources. In addition, mutual interest in cooperation is due to the difficult international situation.*

Key words: *Arctic, Russia, Arctic Council, sanctions, military threats, special military operation, China, cooperation, energy resources, liquefied gas, Northern Sea Route.*

Language: *English*

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Introduction

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In 2022, the strategies and policies of the Arctic countries continued to be improved and updated. Thus, on March 17, India's Arctic Policy was unveiled (Ministry of Earth Sciences... 2022), and on October 7, the White House published a new US Arctic strategy until 2032 called "National Strategy for the Arctic Region" (National Strategy... 2022). If Delhi's position in the future allows India to be considered as a potential partner of Russia in the northern direction, then Washington's strategy, as before, is aimed at consolidating its dominant position in the region, gaining direct access to the Northern Sea Route (NSR), and containing Russian influence. During the opening of the Arctic Circle 2022 Assembly in Reykjavik on October 17, 2022, the Minister of Foreign Affairs of the Faroe Islands, Janis av Rana, presented the Arctic strategy of his autonomy (Faroe Islands launch... 2022), consisting of eight directions. The significance of the document lies in the fact that it temporarily replaces the Danish strategy of 2010. After the adoption in October 2021 of the Joint Communique "More active participation of the EU in creating a peaceful, stable and prosperous Arctic", the European Union opened its representative office in September 2022 Greenland in the city of Nuuk. Its interest in strengthening ties with the Danish region is driven by its rich mineral deposits and its ability to produce and export renewable green energy.

A number of large European and Asian transnational companies reacted to the events in Ukraine after the start of a special military operation, withdrawing from Arctic projects or revising their plans to invest in them. Among them are the Norwegian Equinor, the Anglo-Dutch oil concern British Petroleum, the French oil and gas company Total, the Indian state-owned crude oil and natural gas corporation and the Singaporean company Trafigura. They left Russian projects despite significant financial and image losses. The European Commission has imposed sanctions on the Kolarctic program, which plays an important role in interregional cooperation. Members of the Barents Euro-Arctic Council announced the suspension of interaction with the Russian Federation. Scientific cooperation with the International Council for Science and the International Arctic Science Committee was also significantly limited. The activities of the Russian Federation in the Nordic Council of Ministers have been terminated. In March 2022, seven Arctic Council countries (Denmark, Iceland, Canada, Norway, USA, Finland and Sweden) refused to take part in all meetings chaired by the Russian Federation on its territory, despite the AC's unified strategic plan. Later, on June 8, these states decided to limitedly resume the activities of the AS, but without the participation of Russia. All this ultimately resulted in a boycott of the Russian Federation's chairmanship of the Arctic Council. Against the backdrop of a worsening situation caused by EU sanctions, at the end of June 2022, thanks to the efforts of the Russian Foreign Ministry, it was possible to resolve an acute conflict in connection with Oslo's blocking of cargo heading to the Russian village of Barentsburg to ensure the livelihoods of Russians and employees of the Arktikugol trust. Western states continue to increase their military presence in the Arctic. The situation in the region was greatly complicated by the beginning of the process of Finland and Sweden joining NATO, which strengthened the capabilities of the alliance and created real threats to Russia in the Arctic direction. NATO, as noted by the scientific director of the Institute of the USA and Canada of the Russian Academy of Sciences, Academician of the Russian Academy of Sciences S.M. Rogov, moves on to forming tools to contain Russia in the Arctic region, which has not happened before.

Main part

In the current conditions, it was decided to continue the chairmanship, directing the main efforts to the development of the Arctic territories of the Russian Federation, which already in 2022 led to serious progress. More attention began to be paid to the development of the Northern Sea Route, which affected the volume of cargo transportation, which reached 34 million tons in 2022, and the management of the route. Meanwhile, international transit traffic has declined. Within the structure of the Rosatom state corporation, on the basis of the Headquarters of Maritime Operations, the Federal State Budgetary Institution "Main Directorate of the Northern Sea Route" was created, which made it possible to improve the management of shipping on the Northern Sea Route. In order to ensure its sustainable growth, increase freight transit and increase the efficiency of export logistics routes, the Chairman of the Government of the Russian Federation approved a plan for the development of the Northern Sea Route until 2035. It is planned to allocate 1.8 trillion for its implementation. rubles from various sources. At the same time, paragraph 7 of the document states that the order of the government of the Russian Federation dated December 21, 2019 No. 3120-r "On approval of the Northern Sea Route infrastructure development plan for the period until 2035" is cancelled. The previous version included 11 chapters and 84 specific items for future activities. The updated plan includes about 150 events. The issue of preparing a new plan in 2022 was considered at meetings of Deputy Prime Minister A.V. Novak twice (February 3 and June 9) and with the participation of Prime Minister M.V. Mishustin during an operational meeting with deputy prime ministers on August 1. Priority is given to the development of the cargo base. An application "Forecasted volume of cargo traffic along the Northern Sea Route" has also appeared, which provides for an annual update of the volume of cargo transportation. This plan, which in its content is actually a program for the development of the maritime transport route of the Russian Far North, made it possible to objectively determine that due to the consequences of the pandemic and an insufficient cargo base, we will not be able to transport 80 million tons along the Northern Sea Route by 2024.

Particular attention is paid to the creation of an Arctic orbital satellite constellation, renewal and development of the icebreaker fleet and port facilities. Thus, by 2024, two Arktika-M spacecraft should be launched into orbit, which will provide data on the hydrometeorological situation in high latitudes, as well as three radar observation spacecraft: two Condor-FKA spacecraft, one " Review-R". By 2026, four Express-RV satellites will provide broadband Internet access in the Russian Arctic zone. Without the creation of an Arctic satellite constellation, the safe passage of ships along the Northern Sea Route is not possible.By 2026, four more nuclear-powered icebreakers of Project 22220 will be put into operation, and by 2027, the first icebreaker of the Leader project will be commissioned. The ice-class cargo fleet will be increased more than threefold by 2030. More than 30 tankers, 40 bulk carriers and 22 container ships need to be built. Currently, five nuclear-powered icebreakers escort ships in the waters of the Arctic Ocean. An order was signed to allocate more than 470 million rubles to replace the power equipment of the research vessel Pyotr Kottsov, which is engaged in navigation and hydrographic support of navigation in the Northern Sea Route region. Repair work, which will increase the service life of the vessel by at least 15 years and significantly reduce operating costs, is being carried out in Kaliningrad. On November 22, 2022, the hull of the nuclear icebreaker Yakutia was launched at the Baltic Shipyard. The ship should be handed over to the fleet at the end of 2024. "The icebreakers of this series use waste-free technologies... Emissions of soot or black carbon are only 500 grams per year. If compared with emissions from a conventional coal boiler house, this is 100 thousand times less," noted Deputy Prime Minister of the Russian Federation V.V. Abramchenko, who was present at this event The second serial nuclear icebreaker of project 22220 "Ural" built by the Baltic Shipyard successfully completed the factory sea trials program and on December 3, 2022, set off from the port of Murmansk to the Kara Sea. At the government level, access to preferential loans has been expanded for investors implementing projects in the Far East and the Arctic in industry, transport, and energy, which will significantly reduce the risks of failure of investment projects due to sanctions restrictions. In November, Chairman of the Government of the Russian Federation M.V. Mishustin signed an order to allocate more than 2.6 billion rubles from the federal budget. for the development of social, communal and transport infrastructure in the Komi Republic, Arkhangelsk and Murmansk regions, as well as the Chukotka Autonomous Okrug, which will help improve the socio-economic situation of the Arctic zone. Work has begun on developing the transport infrastructure of the Murmansk region. The boundaries of the priority socio-economic development territory "Capital of the Arctic" have been expanded, which will allow the construction of a marine transshipment complex for liquefied natural gas in the waters of the port of Murmansk. As part of the comprehensive development of the Murmansk transport hub, financing is provided for the construction of a 49.7 km railway to the port of Lavna, where a coal terminal of the same name with a capacity of 18 million tons per year is being built. Attention should be paid to the work on recycling ships that have exhausted their service life. At the moment, four nuclear-powered icebreakers that were previously used on the NSR routes - Sibir, Arktika, Sovetsky Soyuz and Rossiya - are undergoing this procedure. The 25th St. Petersburg International Economic Forum played an important role in developing modern approaches to the development of the Arctic. at which the Ministry of Eastern Development of the Russian Federation presented a broad agenda for the work of regions in the context of sanctions against Russia. The Yamal LNG and Arctic LNG-2 projects are being successfully implemented. A bench testing complex for hydrogen production is being created at the Kola Nuclear Power Plant in the Murmansk region. The world's first Russian floating nuclear power plant, Akademik Lomonosov, is successfully operating, commissioned in May 2020 in the northern seaport of Pevek. Russia has begun creating the international autonomous Arctic station "Snezhinka", which will be a research center on the basis of which it is planned to conduct experiments, research, develop and implement technologies in various fields, primarily in the fight against climate change. Unfortunately, foreign investors are poorly attracted to its construction; mainly budget funds are used.

The progress of fulfilling the assigned tasks must be constantly monitored by the State Commission for Arctic Development. With the creation in 2019 of the Ministry of Eastern Development, which is characterized by activity in setting and solving problems of development and development of the region, the state's attention to Arctic problems has increased significantly. Issues of development of the Arctic zone of Russia have acquired particular importance in light of the unfavorable international events of 2020–2022. Due to the "Covid crisis" and the disruption of global supply chains, the Russian government began to discuss proposals to increase funding for projects in the Arctic Ocean, and several rounds of Western sanctions intensified processes for the development of Arctic territories and modernization of transport corridors to Asia. All this was reflected in the speeches of government representatives at various levels. Employees of the Analytical Department of the Nuclear Industry Communications Center conducted a comprehensive study of speeches by government officials on the topic of Arctic development from October 31, 2021 to November 1, 2022. According to their assessment, five groups of "political figures" are clearly distinguished: namely.

The first side is occupied by the President of the Russian Federation V.V. Over the past year, Putin mentioned or quoted in 100 publications on the topic;

The second line is occupied by the head of the Ministry of Eastern Development of the Russian Federation A.O. Chekunkov and his deputies, who regularly report on the work to improve the legislative framework, the investment attractiveness of the region, and the infrastructure and business projects implemented there;

in the third group we can highlight the Chairman of the Government of the Russian Federation M.V. Mishustin, his deputies Yu.P. Trutnev and A.V. Novak, some federal ministers responsible for achieving the goals of national projects and presidential instructions. The focus of their speeches was the quality of management, financing, scientific and technological support for the development of the Arctic;

the fourth group consists of governors of the constituent entities of the Russian Federation in the Arctic zone;

the fifth - heads of departments who mentioned the Arctic among other subjects of their interest.

In terms of content, very similar motives are noticeable in the speeches of government officials. The focus of the discussion is the implementation of territorial development projects: establishing transport routes, building expensive infrastructure (primarily for petrochemicals and shipbuilding), providing comfortable living conditions for the population. Statements about this are made in connection with the implementation (less often non-fulfillment) of federal plans and programs. Heads of regions and non-core departments practically do not come up with initiatives, and higher-ranking officials mostly "echo" the President of the Russian Federation. The Arctic is a region that is attracting increasing interest from the international community. For a long time it was isolated due to natural reasons, but growing technological capabilities are opening up new prospects for the exploration and development of the region. In addition to large reserves of mineral resources, the Arctic has significant potential for the development of the most convenient transport and communication routes in many senses, not only connecting Europe with the Far East, but also opening access to North America through Canada. Russia has a long border with the Arctic, so its significant economic interests are associated with this region, supported by the growing geopolitical importance of the northern lands. China, being a state not territorially associated with the region in question, is seeking to gain access to the Arctic zone in order to conduct economic activities there, and also due to the growing geopolitical importance of these territories. Russian-Chinese relations are developing today at the level of a comprehensive strategic partnership, and interaction in the Arctic region seems to be a promising direction for both powers. In the context of growing international tension, Russian-Chinese cooperation acquires additional value, however, it also has its limitations, which also relate to the Arctic region. Analysis of bilateral interaction in the northern territories, determination of its trends and prospects is an urgent research task. Russia began exploring the Arctic back in the 17th century. However, until the 20th century, this direction could hardly be called an unconditional priority of its national policy. During the Soviet period, the Northern Sea Route acquired strategic importance and industrial mining began. In the 1990s, in fact, the Arctic complex, inherited by the Russian Federation from the USSR, was abandoned to the mercy of fate, which led to a general severe crisis in the territories of the Far North and an outflow of population. Since the beginning of the 21st century, Russia has undergone a reassessment of the Arctic strategy in terms of realizing the importance of the region for the development of the country. Fundamentally new decisions were made on the development of the Arctic spaces, scientific research expeditions were carried out, designed, among other things, to prove that the Arctic mountain ranges belong to Russia as part of the continental shelf. Already in 2016, the Concept of socio-economic development of the North until 2035 was adopted, which indicated increased attention to the region and the strategic direction of Russian foreign policy. The regulatory framework for Russia's activities in relation to the Arctic consists of:

firstly, “Fundamentals of state policy of the Russian Federation in the Arctic for the period until 2025 and beyond”, then extended until 2035;

secondly, “Strategy for the development of the Arctic zone of the Russian Federation and ensuring national security for the period until 2035.”

The basic principles and directions of Russian foreign policy regarding the Arctic include the following points:

1. The Arctic is the country's strategic resource base, which will contribute to the modernization and socio-economic development of the country.

2. The Arctic is a zone of peace and constructive cooperation.

3. The Arctic is a territory whose ecological system must be preserved.

4. The Arctic is the basis of the country’s unified transport communications system through the development of the Northern Sea Route.

Security for Russia is no less important than the economic development of the Arctic. Thus, the Kola Peninsula is a zone of particular importance in military-political terms. It has access to the Atlantic Ocean and has important military infrastructure facilities. The sea-based nuclear forces of the Russian Federation are also deployed in the Arctic region. Atomic weapons allow the country to feel protected in any situation and ensure deterrence of a potential enemy, which “is not only a key element of Russian military strategy and policy, but also a symbol and guarantee of great power status.” Russia's security forces have been tasked with neutralizing external and internal military dangers and threats in peacetime, ensuring strategic deterrence of potential adversaries, and in the event of an armed conflict, repelling aggression and ending hostilities. Analyzing the state of the military component of Russia in the Arctic zone, it should be noted that it is currently being strengthened, characterized by the return of the Russian armed forces to the northern territories. Thus, at the beginning of 2016, work was completed on the deployment and arrangement of six military bases in the Russian Arctic: on Kotelny Island, Alexandra Land, on Sredniy Island, on the Novaya Zemlya Islands, on Cape Schmidt, on Wrangel Island. Closed-circuit military camps, military airfields, and combat positions of air defense and aerospace forces units have been built or reconstructed there. In addition, in 2018, two separate anti-aircraft missile regiments equipped with the S-400 Triumph air defense system were formed and deployed on the Arctic coast. To protect these systems from enemy air attacks, batteries of the Pantsir-S man-portable anti-aircraft missile system (ZRPK) have been deployed. In addition, a coastal missile division equipped with the Bastion complex is located on Novaya Zemlya. On other islands of the Arctic Ocean and in some mainland areas, coastal missile, anti-aircraft missile and missile and artillery units and subunits are on round-the-clock combat duty. At permanent bases along the NSR, aviation control points and radio, radar and space reconnaissance positions are equipped.

This entire extensive infrastructure is managed by the Joint Strategic Command, created in July 2014 on the basis of the Northern Fleet, which includes a number of units of the Western, Central and Eastern Military Districts. Within a relatively short period of time, this command took the necessary measures to improve combat training and coherence of diverse army forces and assets in the difficult natural conditions of the Arctic. Ensuring military-strategic parity in the region under study is unthinkable without the participation of the Northern Fleet. Today it is the largest, most powerful and modern in the Russian Federation, protects the state border in the Arctic Ocean, ensures the safety of navigation in the coastal part of the Barents and White Seas, being one of the factors in the sustainable functioning of economic and transport systems in the northern and circumpolar latitudes. The missile submarines of the Northern Fleet are the most significant part of Russia’s strategic nuclear forces in the region. In 2015, the flagship of the submarine fleet Yuri Dolgoruky successfully completed a voyage under the ice of the Arctic, and the nuclear-powered strategic submarine cruiser (APKSN) Alexander Nevsky made a trans-Arctic transition to its permanent base in Kamchatka. In addition, almost the entire surface nuclear fleet of Russia is deployed in circumpolar latitudes: the cruiser "Peter the Great", large landing ships "Kondopoga" and "Olenegorsky Gornyak", as well as icebreakers "Yamal", "Vaigach", "50 Let Pobedy" and " Taimyr".

The need to maintain and develop the military component of the Russian Federation in the Arctic is dictated, on the one hand, by the presence of NATO countries in the region, and on the other, by the desire of non-Arctic countries to gain access to the circumpolar seas. The growth of activity of the latter will take place in three directions: financing of civilian projects in the region, commercial and military maritime activities.

The economic, environmental and strategic interests of the Russian Federation in the Arctic region include gaining access to the natural resources of the Arctic (especially hydrocarbon reserves), as well as their exploration and development. The largest and most significant international projects in the field of hydrocarbon production in the Arctic zone are Yamal LNG, Sakhalin-1, Sakhalin-2. Foreign and Russian companies take an active part in their implementation. The Russian Federation considers the Arctic zone to be the country's largest raw material reserve, in which hydrocarbon and mineral resources have remained intact. This fact has not only national, but also worldwide, global significance. The Arctic zone contains the main reserves of the most important minerals, which are decisive for the development of the country's economy. Thus, the explored volumes of industrial gas in this region account for 80% of the all-Russian total. This area contains 90% of the recoverable hydrocarbon resources of the entire continental shelf of Russia, including 70% on the shelves of the Barents and Kara Seas. The PRC's Arctic interests are officially concentrated in the areas of ecology, scientific research, shipping, and exploration and development of natural resources. This policy stems from the desire of the new global power to establish its presence throughout the world, including in the World Ocean. Arctic policy is seen as part of the process of forming a new world order, where China intends to be one of the leading guarantors of the new order. China's interest in the Arctic took shape in 2018, when the option of using the Northern Sea Route was developed as part of the Belt and Road initiative. In general, China's initiative was aimed at developing the shortest Eurasian transport routes connecting the Asia-Pacific region (APR) and Europe without North America. Part of China's Belt and Road project was the development of sea communications across the Arctic Ocean. China officially announced its intention to become a “polar superpower” back in 2019. Later, in 2020, a cooperation agreement was concluded within the framework of the Eurasian Economic Union promoted by Russia and the PRC Belt and Road project. This cooperation also included support for the development of the Northern Sea Route. In 2020, Beijing published extensive material on its foreign policy in the Arctic. It promised to pursue its national interests in the region, and China is now planning its own fleet of modern icebreakers and promoting the Ice Silk Road project. The Northern Sea Route, or, according to Chinese terminology, the “Ice Silk Road”, is considered in the PRC as a priority direction for the development of international cooperation in the Arctic. The key factor here remains saving time on transporting goods and the growing economic and logistics potential of the region.

China's interests in ensuring its energy security are also linked to the development of the Northern Sea Route. The Arctic is potentially a rich source of natural resources, primarily oil and gas, but their development is expensive and environmentally threatening. China counts on the presence of its companies in this area, as well as in the areas of shipbuilding, engineering, financing, and logistics, as it has the necessary technological base to ensure the safety of the region's ecosystem. China has included the Ice Silk Road in its new five-year development plan for the period 2021–2025 and intends to pragmatically participate in relevant Arctic projects that are in line with China's long-term development goals for the period up to 2035.

China dates its presence in the Arctic to its accession to the 1925 Spitsbergen Treaty. The PRC is a member of the International Arctic Scientific Committee, it has organized eight scientific expeditions, and founded its first polar research station in Spitsbergen. China is included as an observer in the Arctic Council, the key organization that controls issues related to the region of the same name. Non-Arctic countries cannot legally lay claim to territory in the Arctic, but major powers such as China are able to influence ongoing processes in this region. The PRC finances Arctic scientific research, related projects and organizes negotiations on free trade with Arctic countries. Unlike other states, China has powerful and free financial capabilities for this. The prospect of developing Arctic, shorter sea routes is one of the main principles shaping the understanding of the growing Chinese interest in the Arctic. Direct routes linking Asia, Europe and America will have a major impact on global trade. For China, three sea routes are key in this regard: the Transpolar Sea Route, the Northwest Passage, and the Northern Sea Route (Northeast Passage). Each is only available for part of the season and requires the use of icebreakers the rest of the year. But ongoing climate change in the Arctic may mean it is a matter of time before routes remain viable for increasingly longer periods.

In 2020, China announced its intention to cooperate in developing Arctic sea routes together with other countries. The PRC emphasized the importance of ensuring the rights of each country to use potential routes for the delivery of goods. This is Beijing's principled position. China advocates that the Arctic region is a common heritage for all mankind. This excludes special rights of the Arctic states, including Russia. The Arctic countries do not agree with this and view China's claims as a threat to their national interests and security. However, the PRC is actively developing its initiatives in this direction and cooperating with small states, in particular with Norway - in the field of scientific expeditions or with Denmark - in the field of investments, which generally helps strengthen the position of the Celestial Empire in relation to the Arctic. China's activity is causing concern in Western countries, which are clearly wary of its attempts to gain a foothold in the Arctic region. For example, Finland refused to lease an airfield in the Arctic to Beijing, despite the economic attractiveness of the proposal, while the Western “Five Eyes” Intelligence Sharing Alliance, whose members include the USA, Canada, Australia, Great Britain, and New Zealand, announced its intention fight Chinese influence in Greenland, pointing out that Beijing already controls about 90% of the island's rare earths. In Greenland, there is a clash of interests between different countries, as Chinese, American, and European organizations plan to explore energy resources on the continental shelf. Chinese-controlled

London Mining intends to develop large-scale iron ore mining in the southwest of the island and is proposing infrastructure and investment. Uranium deposits have been discovered in the south of Greenland, in which the United States and China are showing interest. There is also a plan for the development of new promising projects within the framework of aluminum production. In Greenland, Chinese activity and rivalry with other countries is causing debate as economic benefits come with concerns about environmental costs. In Denmark, too, the resolution of issues regarding Greenland is ambiguous. The extraction of raw materials was initially based on the availability of cheap Chinese labor, but Denmark is keen to retain the right to regulate immigration issues on the island.

The PRC considers Russia as its priority partner in the Arctic. Beijing calls Moscow's political stability a distinctive feature of cooperation, which serves as a guarantee of its implementation of agreed decisions and ensuring non-interference by third forces. This factor is extremely important due to the existing tension between Russia and the West and the growing confrontation between China and the United States. In the context of sanctions pressure on Russia, China can provide it with investments and technologies for the development of the Arctic region to create new transport routes and implement infrastructure projects. The capabilities of the PRC can give impetus to the modernization of the territories of the North, including the development of ports, construction of infrastructure, creation of new routes for shipping, exploration and extraction of natural resources. A natural limitation to cooperation is the continued possibility that the Arctic will be used by Beijing as political leverage to establish itself as a new Arctic power. At the same time, the Russian Federation remains the largest military force in the northern territories, which allows it to worry less about competition from participants in projects in the Arctic. Russia asserts its claims to exclusive control over the Northern Sea Route, justifying them by its territorial position and the presence of the longest access to the Arctic region.

The development of the Ice Silk Road as part of China's Belt and Road project corresponds to Russian strategic interests in the context of the formation of the Russian Northern Sea Route as a more competitive project on a global scale under Russian control. Such a scenario will provide an opportunity for Russia to further strengthen its presence in the Arctic region, and for China to participate in its development, but not as a competitor to the Russian Federation. The Ice Silk Road is viewed by China as a commercial and geopolitical project, but for Russia it remains a vital area of national interests and security. Noting the weak population of the northern regions, which sharply contrasts with its growing geopolitical role, Beijing sets the task of improving the demographic situation, developing Arctic ports, their technical equipment, which will extend their operation and establish policies for migrants. Meanwhile, the Russian Federation and China are successfully implementing joint projects to develop the natural resources of the northern territories. The Arctic LNG-2 project is aimed at establishing the production of liquefied natural gas in a volume of 19.8 million tons per year. During its implementation, three technological lines were built and it is planned to produce stable gas condensate with a total volume of up to 1.6 million tons annually. China provided Russia with investments and innovative technologies that made it possible to organize gas production and processing in Arctic conditions. The Utrenneye field, which is located in the Yamalo-Nenets Autonomous Okrug of the Russian Federation, has become the main resource base for Arctic LNG-2. The project itself was launched in 2018, when the main technical work was completed and all project documentation was ready. Following this, the process of technical and engineering preparation and the actual construction of facilities began, including drilling wells and building an embankment with the possibility of mooring Arctic ships. The project cost is estimated at a total of 21.3 billion US dollars, based on the 2019 situation. Another project is Yamal LNG. It involves work on the extraction, liquefaction and supply of natural gas. Its main resource base is the South Tambeyskoye field, where proven and probable natural gas reserves reach a volume of 926 billion cubic meters. m. The South Tambeyskoye field itself is located in the northeastern part of the Yamal Peninsula. It was discovered in 1974 and is now considered part of the West Siberian oil and gas province. A plant should be built on this territory that will produce liquefied natural gas. In addition, it is planned to provide it with transport infrastructure, including the sea and air port of Sabetta. Thus, Russian-Chinese cooperation in the Arctic has come to the forefront of bilateral relations and has become one of the most popular areas of interaction. Meanwhile, China's Arctic policy is constantly facing two main obstacles, namely:

firstly, its activation is perceived extremely ambiguously by other Arctic countries and centers of power. At the same time, Denmark, counting on Chinese investment, states that China has legitimate scientific and economic interests in the Arctic. However, in most countries there is some degree of wariness;

secondly, the practical implementation of the PRC initiative is hampered by the lack of access to the Arctic, which limits its potential. Canada is not inclined to give privileges to China in its attempts to gain access to the Northwest Passage, and Russia has no intention of relinquishing control of the Northern Sea Route.

As part of the "Concept of maritime cooperation" published by Beijing in 2017, which became part of the "One Belt and One Road" initiative, the Chinese side formulated priority directions for the development of northern communications, including the "blue economic corridor" across the Arctic Ocean. It should reflect the participation of the PRC in the development of the Arctic region. This document became the first factual and official confirmation of Beijing's intentions regarding the Arctic. At the same time, the PRC takes into account the role of the Arctic in monitoring outer space, its military-political deterrence potential in the northern geopolitical space. China intends to build on Russian experience and its infrastructure in this regard.

Since 2010, Russia has hosted the International Arctic Forum "The Arctic – Territory of Dialogue," which has become the largest platform focused on joint discussion of current problems and prospects for the development of the region by representatives of interested countries, including China.

In July 2017, the Russian Federation and China jointly announced that their cooperation also concerns the Northern Sea Route ("Ice Silk Road"). As part of the implementation of the agreements reached, the construction of "strong points" of the Ice Silk Road began, which Beijing considers as the most promising areas of strategic cooperation. According to A.A. Fedorova, the "Ice Silk Road" of the PRC, after joint modernization work, will reduce transportation time from 33 to 20 days, and the cost of transport costs will be reduced to 50 thousand dollars per day. Along with this, the Northern Sea Route is still characterized by harsh climatic conditions, therefore, the possibility of its use is currently limited to only a few months a year. However, for Russia it represents the main transport artery in the Arctic, therefore, Moscow is interested in cooperation with Beijing in this area.

The role of the Arctic in the modern world is steadily increasing. Global warming is causing the ice to melt faster, and it is predicted that by 2040 the region could be ice-free. The melting of Arctic ice will have a direct impact not only on the environment, but also on geopolitics. This means a sharp intensification of the international struggle for dominance over the North Pole, in which China will play an active role. Natural resource reserves, primarily oil and gas, will become more accessible, which is of great importance in the context of their demand in the Chinese economy.

In the future, the Northern Sea Route, which is now used exclusively by Russia and only at a certain time, will be transformed into a year-round transport route with huge trade potential and the prospect of military use. The route from Asia to Europe could be reduced by 35-40% compared to a similar route across the Indian Ocean. Russia will be able to export its own liquefied natural gas much more easily, increasing the availability of supplies from the Arctic fields of Siberia.

Thus, the Russian Federation and the People's Republic of China consider the Arctic as one of the most promising areas for cooperation, based on the role of the region in global geopolitics at the present time and its existing potential, which will be updated in the future.

Russia, as an Arctic state with the longest common border with the northern territories, is expanding its presence in the Arctic, modernizing the Arctic legacy of the USSR and ensuring its military-political and economic interests. Moscow offers Beijing participation in its Arctic projects, primarily in the development of natural resources and the development of communications along the Northern Sea Route. For China, the opportunities provided by cooperation with Russia are also vital within the framework of the implementation of the Ice Silk Road initiative, and Chinese investments for Moscow, currently, due to the implementation of Western sanctions policy, have no alternative.

Conclusion

Sanctions of the United States and the European Union against the Russian Federation and the activation of NATO in the region negatively affected the economic development of our country, cooperation and interaction in the Arctic, but "... none of what our enemy predicted for us happened," the Russian President noted at a meeting with members of the Government of the Russian Federation on January 11, 2023. The withdrawal of seven AU countries from the program and activities of the Russian Presidency of the Council increased uncertainty regarding plans for the development of the Arctic, violated solidarity, undermined mutual trust, and increased tension. But even in these conditions, Russia needs to complete its chairmanship and hand it over to Norway with dignity, although there may be other options. The situation in the Arctic continues to develop dynamically, in some aspects it is associated with increased risk and uncertainty, a decrease in confidence in the military field, which is due to a possible repetition of Ukrainian scenarios in the north. At the same time, the real impact of the NWO on the Arctic region can only be determined by its final results. In response to NATO's actions, Russia needs to continue to take the necessary measures to strengthen national security, solve problems of restoring its military infrastructure, and provide favorable conditions for the activities of economic entities, including the unimpeded functioning of the Northern Sea Route. In the current conditions, it is advisable to develop a separate program of cooperation between Russia and Eurasian partners and the BRICS countries in the Arctic. Thus, mutual interest in effective interaction in the field of development of Arctic territories and development of their potential can become a solid basis for long-term planning for the implementation of strategic initiatives of the Russian Federation and China in the Arctic.

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ABOUT THE CHEMISTRY OF GENESIS AND HYDRODYNAMICS OF MINERAL WATERS OF THE SOUTHERN SLOPE OF THE CAUCASUS

***Abstract**: The present paper shows, on the one hand, a close relationship between the genesis of the chemical composition of the carbonated mineral waters of the southern slopes of the Caucasus and hydrodynamic processes, and, on the other hand, between the lithology and tectonics of the rocks of the region. In particular, alkaline or the so-called sodic waters are formed in Lower and Middle Jurassic shale strata, alkaline-saline ones - in Bajocian volcanic-sedimentary formations, and saline-alkaline and partially alkaline-saline ones - in Upper Jurassic - Lower Cretaceous carbonate flysch. Due to the lithological features of the region, the circulation of mineral waters takes place mainly in fractured, fractured-veined and fractured-porous aquifers.The dischargeof these waters almost entirely depends on the flow of carbon dioxide and the so-called "gas-lift" effect.*

***Key words**: Caucasus, carbonated waters, genesis, hydrodynamics.*
***Language**: English*
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Introduction

According to the concept of modern geotectonic division, the southern slope of the Caucasus is a fold system of the Caucasian segment of the Alpine-Himalayan mobile belt [1]. The hydrogeological peculiarities of theyoung fold tectonic unit, along with other factors, are determined by the nature of its geological structure.

The southern slope is distinguished by the abundance of exit points of carbonated mineral waters of different chemical composition. Since the end of the 19th century, researchers have become interested in them. Mainly, the springs that were relatively easy to access have been studied. S. Chikhelidze [2] collected the related material availablein the printed sources and geological funds, added the results of his own research and published them as one paper in 1961.

A long time has passed since the on-site research of mineral waters of the region was conducted. During this time, as a result of natural events and human economic activities, it is not excluded that in some cases the location of springs and the chemical composition of waters have been changed. Considering the abovementioned, in 2018-2022 we conducted a monitoring study of the mineral waters of the region. Correspondingly, it was found out that: a) as a result of landslides or floods several springs were covered with proluvial or alluvial material; b) Gas-saturated mineral water flowed from boreholes dug for different purposes, and sometimes even erupted in the form of a fountain (borehole in the valley of the river Nakra (Fig. 1)).

Figure 1. The Borehole in River Nakra Valley.

The gaseous component of the mineral waters of the southern slope is represented only in the form of carbon dioxide [3, a]. As it is known, when CO_2 dissolves in water it forms carbonic acid that is considered to be a weak acid. However, it has sufficient power to precipitate sedimentogenic salts from sedimentary rocks and to leach chemical elements, primarily sodium, from the friction material in faultzones. As a result, the infiltration fresh water becomes mineralized.

The chemical composition of the mineral waters of the region is determined after carbon dioxide passes through them.The saturation of infiltration waters with CO_2 leads to the intensification of the leaching of rock layers and the processes of precipitation of the absorbed complex. As a result of leaching mainly sodiumcan enter the groundwater through finely dispersed (shale) fissured rocks, as well ascalcium, magnesium, and rarely iron through porous fissured ones (stones, carbonates, etc.); through the precipitation of the absorbed complex from the porous rocks mainly chlorine and sodium are transferred into the water.

A close relationship between the chemism of mineral waters and the lithology of geological formations is clearly revealed, especially in waters of medium mineralization (5.0 - 15.0 g/l). The following regularities have been found: a) Alkaline or soda waters (with $NaHCO_3$ content more than 75% eq.) are almost all related to Lower and Middle Jurassic shale strata; b) Alkaline-saline waters (with approximately equal content of HCO_3 and NaCl) -to Middle Jurassic (Bajocian) volcanogenic-sedimentary formations and c) Saline-alkaline waters (NaCl> HCO_3) -to the Upper Jurassic-lower Cretaceous carbonate flysch. Of course, there are exceptions. In particular, in places where there are layers of sandstones in the shale stratum. Sedimentogenic NaCl gets into ground water. Less mineralized (M<3.0 g/l) waters associated with carbonate flysch, they are mostly calcium or calcium-magnesium.

As a result of the mixing of medium mineralized waters with groundwater, the quantity and flow rate of low mineralized waters of various chemical composition often exceeds the quantity of the first ones.

It should be noted that within the fold system of the Caucasus southern slope, bad hydrogeological conditions have developed for the circulation of underground waters. This is caused, on the one hand by low filtering properties of the rocks and on the other hand by intensive sedimentation and disturbance of geological formations, in which layers are often overturned. Here, the integrity of the layers and the alternation of water-permeable and waterproof horizons, characteristic of "quiet" folded zones, are broken, and therefore there is no place for the circulation of pressurized groundwater.

The presence of fissure, fissure-vein and porous-fissure reservoirs in open hydrogeological structures determines the nature of the hydraulic processes of the region. Discharge of deep circulating groundwater (flowing to the surface of the earth) occurs in fault and shear zones, especially at fault junctions. The upward circulation of groundwater in the South Slope fold system is entirely dependent on the abundant flow of CO_2. The water-gas suspension formed during their mixing flows to the surface due to the “gas lift” effect.

From the hydrogeological point of view, the southern slope has unfavorable conditions for the infiltration and circulation of the groundwaters, which is caused, on the one hand, by the low water permeability of the rocks of the region and, on the other hand, by the intense folding and disjunctive disturbances of the geological formations. Here the layers are often upside-down (overturned), and sometimes they are recumbentwith transverse-slip and oblique-slip faults. Based on the lithological characteristics of rocks fractured, fractured-veined and fractured-porous aquifers (water-bearing horizons) can be observed here.

Natural exit points of mineral waters in the region are usually associated with fault zones, especially with the knots of intersecting faults.The upward movement and surface runoff (discharge) of these waters is almost entirely due to the abundance of deep carbon dioxide in the fold system of the Southern Slope.The specific weight of the suspension formed as a result of the saturation of mineral water with CO_2 is <1.0 t/m^3, and it appears in the form of an ascending spring due to the natural "gas-lift" effect.

Due to the special role of carbon dioxide in formation and distribution of mineral waters of the region, the issue of its genesis cannot be ignored. Earlier it was stated that CO_2 is of abyssal origin.This is true, but the source of its formation is unclear. A. Vinogradov expressed a more or less justified opinion on this issue [4]. He believed that carbon enters the earth's crust as a result of global processes of mantle degassing.

As mentioned above, exit points of CO_2-saturated waters are spatially linked to fault zones. Particularly intense gas flow is observed in the areas of magmatism centers of Tertiary, often of Holocene period. Such as: the effusives of Keli Plateau, the cones of extinct volcanoes preserved in the form of peaks (especially in the upper reaches of the Terek River). It seems that on the southern slope of the Caucasus we have CO_2 of two origins: the first one - coming from the mantle, andthe second one -released from carbonaceous rocks as a result of contact metamorphism. Based on previously conducted carbon isotope studies, it was concluded that most of the carbon associated with the carbonated waters of the region is of the mantic origin, while the ones of the metamorphic origin are relatively small in number and are represented locally only [3, b].

Mineral waters of the southern slope are very attractive in terms of consumption due to their chemical composition, which determines their pleasant taste and medicinal properties. The analogues of the approved mineral waters, such as “Borjomi”, “Sairme”, “Essentuki” can be found here [5]. Some of them were bottled ("Utsera", "Kazbegi", etc.). Several balneological resorts operated here as well. Currently, the level of using valuable natural resource of the region – carbonated mineral waters – is very low. The industrious businessman can bring a lot of benefits both to himself and to the region. Along with mineral waters, there are excellent natural conditions for establishing balneological resorts and creating a wide network of mineral water bottling enterprises.

Finally, based on the actual identical nature of the geological structure and the history of the development of young-fold systems, it can be assumed that the regularities of the chemistry of genesis and hydrodynamics of carbon dioxide mineral waters of the southern slope of the Caucasus- of one of the components of the Alpine folded belt, are the same for other zones of this belt.

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USE OF DRONES IN THE AGRICULTURAL SECTOR OF THE KYRGYZ REPUBLIC: EXPERIENCE OF SOME COUNTRIES

Abstract: *This article discusses current issues of the use of drones, hereinafter UAVs, in agriculture of the Kyrgyz Republic based on the experience of some countries. The advantages and possibilities of using drones in agriculture are analyzed, as well as the problems and limitations that agricultural enterprises face when introducing this technology. The article also discusses examples of the successful use of drones in the agricultural sector of other countries and offers recommendations for Kyrgyzstan.*

Key words: *agriculture, drone, UAV, foreign experience, government support, share of business entities.*
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Introduction

Agriculture is an integral part of the economy and society of any country, including Kyrgyzstan. It is of great importance not only from an economic point of view, but also from a social and cultural one. Agriculture in Kyrgyzstan not only provides food security and economic development, but is also a traditional way of life for many rural residents. It determines the sociocultural identity of the local population and plays an important role in preserving traditions and customs. The majority of rural residents in Kyrgyzstan have been engaged in agriculture for more than one generation, passing on knowledge and experience from parents to children. This helps to preserve rural culture and traditions, as well as strengthen ties in rural communities. In addition, agriculture in Kyrgyzstan plays a key role in rural development, providing residents with access to vital resources such as food, water and labor opportunities. Support and development of agriculture contributes to improving the quality of life of the rural population and sustainable development of these territories. Thus, agriculture in Kyrgyzstan is not only an economic sector, but also a sociocultural phenomenon that determines the way of life and the development of rural communities in the country.

Table 1 - Share of agriculture, forestry and fisheries of the Kyrgyz Republic in the economy, for 2019-2023.[1]

	2019	2020	2021	2022	2023
Share of agriculture in GDP, %	10,4	12,2	12,4	11,0	9,7
Share of operating economic entities in agriculture, forestry and fish farming in the total volume of operating economic entities, %	63,0	62,8	63,0	63,0	62,8
are of people employed in agriculture, forestry and fishing in the total number of people employed in the economy, %	23,0	20,3	21,8	22,0	20,3

As the data in Table 1 shows, although the share of operating economic entities in agriculture, forestry and fish farming decreased during the period under review from 63.0% to 62.8% or by 0.2%, it (the share) remains high in the total volume of operating economic entities in country, i.e. more than half (62.8%) of business entities are engaged in agriculture.

In civilized countries, the successful development of this industry is often ensured by an effective combination of government regulation, self-regulation and sound financial and credit policy. Government regulation may include various instruments, such as subsidies, benefits, tax incentives, purchases of products at competitive prices, programs to support agricultural enterprises, etc. Government intervention may be particularly important to address issues related to market instability, crises, natural disasters, access to finance and other aspects. Self-regulation, that is, the actions of agricultural producers themselves or their associations, is also important. This may include the creation of cooperatives, associations, production and trade associations that can provide cost reductions, increased competitiveness, improved product quality and access to new markets. Competent financial and credit policy also plays an important role in the development of agriculture. Providing affordable and long-term lending, developing insurance programs, investing in infrastructure, supporting innovation and developing sales markets - all this helps improve the financial condition of agricultural enterprises and stimulates their development. Thus, modern development of agriculture requires an integrated approach, including effective government regulation, self-regulation and sound financial and credit policy aimed at creating favorable conditions for the sustainable development of this important industry.

For the purpose of state support for agricultural producers, the Cabinet of Ministers of the Kyrgyz Republic provides assistance with preferential lending, so Table 2 shows the amounts of preferential lending for three sectors of agriculture in 2023.

Table 2 – Volume of preferential lending to agricultural producers through commercial banks of the Kyrgyz Republic in 2023.

Name of funding source	Crop production (thousand soms)		Livestock (thousand soms)		Agroprocessing (thousand soms)	
	Quantity of credits	amount of credits	Quantity of credits	amount of credits	Quantity of credits	amount of credits
OJSC "Aiyl Bank"	948	445464	1541	881562	79	191457
OJSC "RSK Bank"	1115	439260	1937	890900	42	120730
JSC "KICB"	200	74155	293	147235	14	61500
OJSC «Capital Bank»	53	10305	153	29297	2	1500
OJSC "CB Kyrgyzstan"	131	29090	195	45425	8	29445
OJSC "Kyrgyzkommertsbank"			2	4000		
Total	**2447**	**998274**	**4121**	**1998419**	**145**	**404632**

[1] According to materials from the website of the National Statistical Committee of the Kyrgyz Republic [Electronic resource]. - Access mode: https://www.stat.kg/ru/opendata/category/2314/

State support for agricultural producers, especially farmers in the form of preferential lending, goes towards creating favorable conditions for them by providing them with the necessary material and technical means, fuels and lubricants, fertilizers, agrochemicals, etc., but nowhere is there any mention of the purchase of new innovative (information) technologies.

Of course, issues of increasing productivity, quality of seed material, proper methods of tillage, soil water regime, application of fertilizers, control of pests and plant diseases, as well as weeds are key to the successful development of agriculture in Kyrgyzstan. Effective management of these aspects can significantly improve the productivity and economic performance of agricultural production. Crop yields, animal productivity, labor costs, product quality, land productivity, capital productivity, labor productivity - all these indicators play an important role in assessing the efficiency of agriculture. Increasing these indicators requires an integrated approach, including the introduction of modern technologies, training of agricultural workers, scientific research and innovation. In this regard, instead of purchasing expensive agricultural machinery (tractors, cultivators), it would be advisable to purchase new, high-tech, efficient technologies, such as unmanned aerial vehicles.

UAV, drone are different names for the same device - an unmanned aerial vehicle, which is controlled using a remote control or autonomously. The main difference between these terms is what type of aircraft they describe. UAV (unmanned aerial vehicle) is a general term that can be used to describe any unmanned aerial vehicle, regardless of its design or flight principle. This can be either a quadcopter or another type of drone. Drone is a narrower term that is usually used to describe an unmanned aerial vehicle with a multi-rotor design, such as a quadcopter or multicopter (tri-, quad-, hexacopter). A drone often has four or more rotors, which give it vertical takeoff and landing and control in all directions. A quadcopter is a specific type of drone that has four rotors and uses the principle of multi-rotor stabilization to fly. Quadcopters usually have a simple design and can be used for both recreational and professional purposes such as aerial photography or videography. So, all of these terms can be used interchangeably, but have some differences in how they describe an unmanned aerial vehicle.

In recent years, the use of such aircraft in various spheres of life has become widespread. One of the promising areas of application of this technology is the agricultural sector we are considering.

The history of using drones in agriculture begins relatively recently, but their use is becoming increasingly popular. In the early 2000s, drones began to be used in agriculture to monitor crops and harvests. They were used to produce high-quality aerial photographs that helped farmers analyze crop health, determine yield levels and predict potential problems. Drone technology has advanced significantly in developed countries since 2010, leading to increased use in agriculture. Drones have begun to be equipped with specialized cameras and sensors that allow for more detailed and accurate monitoring of crops and harvests. They can detect plant diseases, determine soil moisture levels, analyze weather data and other parameters that help farmers make more informed decisions.

Drones have great potential to improve agricultural production efficiency, reduce costs and improve product quality. For example, let's look at the experience of some countries in using drones in the agricultural sector and evaluate its applicability in Kyrgyzstan.

Advantages of using drones in the agricultural sector.

The use of drones in agriculture can lead to significant cost efficiencies. Here are some reasons:

A). *Increased Productivity:* Drones can help agricultural businesses increase productivity. They can quickly and accurately carry out tasks such as monitoring crop areas, assessing plant health, determining yield levels, etc. This allows agricultural businesses to make more informed decisions and improve the efficiency of their operations.

B). *Reduced Costs:* The use of drones can reduce the costs of agricultural operations. For example, drones can help determine the optimal time to water, reducing water and energy costs. They can also be used to identify areas that require pesticide or fertilizer treatment, allowing agricultural operations to reduce costs for these materials.

C). *Increased accuracy and quality of work:* Drones can help improve the accuracy and quality of agricultural work. For example, they can be used to more accurately distribute fertilizers or pesticides, which can lead to increased yields and reduced risk of environmental damage.

D). *Risk Reduction:* Drones can help agricultural businesses reduce risks associated with weather conditions and plant diseases. They can be used for early detection of plant diseases or pests, which allows the necessary measures to be taken to eliminate them and prevent damage to the crop.

However, it is worth noting that the use of drones in agriculture also requires significant investment in equipment and personnel training. Therefore, to assess the cost-effectiveness of using drones in a specific agricultural enterprise, it is necessary to conduct an appropriate cost-benefit analysis.

Experience of some countries.

Statistics on drone use in agriculture by country:
USA: According to the American Drone Association, agricultural drones make up about 22% of all registered drones in the United States. They are used

to monitor crops, monitor crop condition, determine yield levels and predict weather conditions.

China: China is one of the leading producers and consumers of agricultural drones. They are widely used in the country for monitoring crops, spraying fertilizers and pesticides, and watering fields.

Brazil: Brazil is also actively using drones in agriculture. They are used to monitor the condition of crops, determine yield levels and determine the need for fertilizers and pesticides. European Union: In the European Union, drones are used for crop monitoring, soil analysis and water control. They are also used to determine crop yield levels and predict weather conditions. Overall, the use of drones in agriculture continues to grow around the world. They help farmers increase their efficiency, improve crop quality and reduce production costs.

In January 2013, the Agricultural Aviation Industry Innovation Technology Alliance was established in Sanya City, Hainan Province (PRC) to create a technical exchange platform. This organization includes universities, research institutes and enterprises that are mainly engaged in research into related technologies and products to promote the comprehensive application of agricultural drones. A demonstration of the development and application of a spectral remote sensing platform for low-level crop imaging was created, and an application model based on low-altitude hyperspectral remote sensing information was developed. At the same time, a remote sensing spectrometer inversion model for disaster visualization was developed.

The Hohhot District Administration of Inner Mongolia and Northwestern A&F University worked with unmanned aerial vehicles to transport experimental equipment related to obtaining soil moisture and crop moisture information at two test sites. This made it possible to expand the possibilities of automation of irrigation zones and their directions.

In India, drones are used to monitor droughts and monitor water resources, which helps in efficient use of water and prevents the negative effects of drought. In a bid to make drones more accessible to farmers, India's Ministry of Agriculture has announced revised guidelines for the Sub-Mission for Agricultural Mechanization (SMAM) scheme. The guide will make this technology accessible through assistance in purchasing, leasing and demonstrating agricultural drones. The SMAM scheme was launched in 2014-15 with the aim of increasing access to agricultural mechanization for smallholder farmers as well as for regions where availability of agricultural energy is low.

In South Korea, "instead of farmers striding through rice fields with canisters of herbicide on their backs, people are now increasingly seeing drones circling the fields spraying fertilizer for the upcoming harvest," writes Chang Yoo Chun, Staff Writer for Korea.net. Access mode: [https://russian.korea.net/NewsFocus/Policies/view?articleId=137634]

Agricultural drone inspection guidelines and standards have been set and announced by the Ministry of Agriculture, Food and Rural Development to encourage the use of drones in this area. In accordance with the issued guidelines and standards, agricultural drones will undergo various structural and functional tests, during which their performance will be verified. Basic metrics such as takeoff, landing and mid-air stops will also be tested.

Agricultural drones that pass the tests will be approved and receive support from the ministry. Farmers willing to purchase drones will receive a credit of up to 80% of the price.

Recommendations for Kyrgyzstan.

However, despite all the advantages, the use of drones in the agricultural sector also faces a number of problems and limitations. First, the cost of purchasing and maintaining drones can be high, creating additional costs for agricultural businesses. Secondly, there is no legal framework regulating or encouraging the use of UAVs in agriculture. Third, there is a need to train personnel, and obtaining the appropriate permits and licenses to operate drones can be complex and time-consuming.

Based on the experience of other countries, a number of recommendations can be proposed for the introduction of drones into the agricultural sector of Kyrgyzstan.

a) It is necessary to analyze the economic efficiency of using drones and determine the specific benefits for agricultural enterprises.

b) It is necessary to develop training and certification programs for personnel to ensure qualified use of drones.

c) It is necessary to analyze the geographical features of Kyrgyzstan and determine the opportunities and limitations for the use of drones in various regions of the country.

d) And most importantly, the Ministry of Agriculture needs to develop a bill that regulates and encourages the use of UAVs by farmers.

Conclusion.

The use of drones in the agricultural sector has great potential for increasing the efficiency of agricultural production and improving product quality. However, before introducing this technology in Kyrgyzstan, it is necessary to take into account the problems and limitations, as well as study the experience of other countries and develop appropriate recommendations.

Farmers across the country will be interested in drones due to their productivity, which reduces labor costs and pest control time. This is one of the reasons why the entire scientific world and farmers' representatives are increasingly demanding that the

Kyrgyz government establish guidelines and standards for these mechanisms.

With the above information, it is not difficult to understand that drones play an important role in the development of the agricultural sector. At the same time, the application of UAVs in agriculture at home and abroad concentrates on crop protection and is rarely used in other fields of agriculture, especially in scientific research, agricultural product quality assurance and e-commerce. In the future, the application of UAVs in agriculture is expected to inevitably expand to all types of agriculture, providing more beneficial technical support to the modern smart agriculture sector.

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Issue **Article**

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TRACTION IN LOADED SIMPLE BOLTS

Abstract: *Visualization of the loaded state of a simple bolt in a joint was demonstrated by the authors in the article. The degree of deformation of the standard product was displayed by vectors of the ratio of force to the area of the working surfaces of the bolt.*

Key words: *bolt, traction, joint, load.*

Language: *English*

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Introduction

The bolted joint provides a detachable coupling of several parts with bolts of various configurations. Bolts are standard products that must be manufactured in accordance with official documents [1-4].

During operation, the bolts are subjected to various deformations (shearing, crumpling, and stretching). Depending on the loading conditions of the bolted joint, the dimensions, material, accuracy and other characteristics of the bolts are selected by calculating analytical equations, conducting an experiment or modeling in computer programs of engineering analysis [5-10]. By changing the shear force of the jointed parts, the intensity of the contact deformation of the bolt surfaces is determined. The degree of bolt loading can be represented by the force/area ratio, which allows us to estimate not only the magnitude of the acting force on a specific surface, but also to determine the type of deformation.

In this article, a vector array of the load distribution of simple bolts with constant shear force of the mated parts was obtained using the computer program.

Materials and methods

The intensity of loading of the bolts that connected the flange to the pipe was studied. A constant transverse force acted on the flange. All parts of the joint were made of structural steel having the following properties: density – 7850 kg/m^3, Young's modulus – 200 GPa, Poisson's ratio – 0.33. The fastener was a simple bolt without a thread with the following dimensions: diameter of the head – 38 mm, thickness of the head – 15 mm, nominal diameter – 21.2 mm, bolt length – 34 mm. A washer with a thickness of 4 mm and a hole diameter of 25 mm was placed under the bolt head. The bolt stress area was 353 mm^2. The calculation was carried out in the Comsol Multiphysics software.

Results and discussion

The traction is the ratio of the acting force to the area of the contact surfaces of the bolt. The traction vectors in the loaded bolt were shown in the Fig. 1. The vector length determines the amount of force. It is noted that the maximum forces occur along the bolt rod and at the junction of the rod and the head. At the same time, forces act at a certain angle at the boundary, thereby causing a shift in the layers of the bolt material. The forces act in two directions, causing both tensile and compression deformation. At the same time, the compression deformation of the bolt is smaller in magnitude than the tensile deformation (vectors at the boundary of the end face of the bolt rod). A lower intensity of loading is noted on the surfaces of the bolt head. Thus, the greatest deformation of the material occurs along the axis of the bolt with a predominance of stretching.

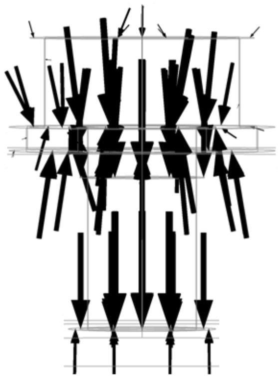

Figure 1. Traction vectors in the loaded simple bolt.

Conclusion

Loaded bolts experience tensile, compression and shear deformations. A visual representation of the traction ratio makes it possible to analyze the approximate effect of tensile, compressive and shear forces on the contact surfaces of the simple bolt without a thread. The results obtained will be useful to design engineers when designing fasteners for technological equipment.

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EXPERIMENTAL STUDY OF SHRINKAGE OF A PLASTIC PART MADE BY 3D PRINTING

***Abstract**: The shrinkage of linear and diametrical dimensions of a PLA plastic part made on a 3D printer by FDM was analyzed in the article. The smallest shrinkage value in percentage terms was noted after measuring the overall dimensions of the part, the largest shrinkage value was noted after measuring small diameter holes.*

***Key words**: 3D printing, PLA, shrinkage, dimension, part.*

***Language**: English*

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Introduction

Additive technologies in modern manufacturing make it possible to produce high-quality parts with complex configurations in small batches. The possibility of manufacturing products from various materials (plastic, metal, rubber, etc.) with a high degree of flexibility makes this technology more efficient than traditional methods of manufacturing parts.

Layered 3D printing of parts on 3D printers is widely used in industry and other fields. PLA-plastic [1] has good strength at a low cost, which leads to the widespread use of the material in the manufacture of parts. Modern reviews of the possibilities of 3D printing of PLA plastic parts have been carried out by researchers, a number of which are presented in the works [2-6].

However, along with the advantages of the method in 3D printing (as in any thermodynamic process of manufacturing parts), there is a change in the dimensions of plastic parts caused by volumetric and linear shrinkage [7-9]. The value of shrinkage depends on the plastic used. At the same time, the shrinkage range of PLA is minimal. Determining the shrinkage value depending on the size of the element located on the outer or inner surfaces of the physical part will allow you to adjust the final dimensions of the projected electronic model of the part for further import to a 3D printer.

Materials and methods

The linear shrinkage of the part made of PLA on a 3D printer of the PICASO Designer Classic model [10] was subject to the study. To manufacture the part using 3D printing, a three-dimensional model of the "plate" type part with nine through cylindrical holes of various diameters was created. The following overall dimensions of the part were adopted: length – 104 mm, width – 20 mm and thickness – 7 mm. The diameter of each subsequent hole increased by 1 mm, starting from 2 mm. After saving the solid-state model of the part to the STL format, the following parameters were set for 3D printing: one nozzle with a diameter of 0.5 mm; wire diameter – 1.75 mm; number of layers – 70; layer height – 0.1 mm; width of the internal filling line – 0.5 mm; internal filling density – 20%; filling pattern – grid (2D); intersection with perimeters and shell – 15%; number of perimeters – 3; indent from the edge when smoothing – 0.1 mm; pattern – zig-zag; feed ratio – 10%; regular clearance – 0.3 mm; print speed – 20 mm/s. The plastic and the table were heated to temperatures of 210 and 50 °C, respectively. It took 2 hours and 49 minutes to print the physical part with a wire consumption of 3324 mm.

The part model built in the "Kompas" software and prepared for 3D printing in the "Polygon X" software is shown in the Figs. 1-3.

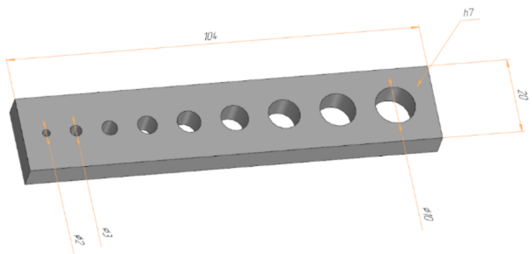

Figure 1. The solid-state model of the part created in the "Kompas" software.

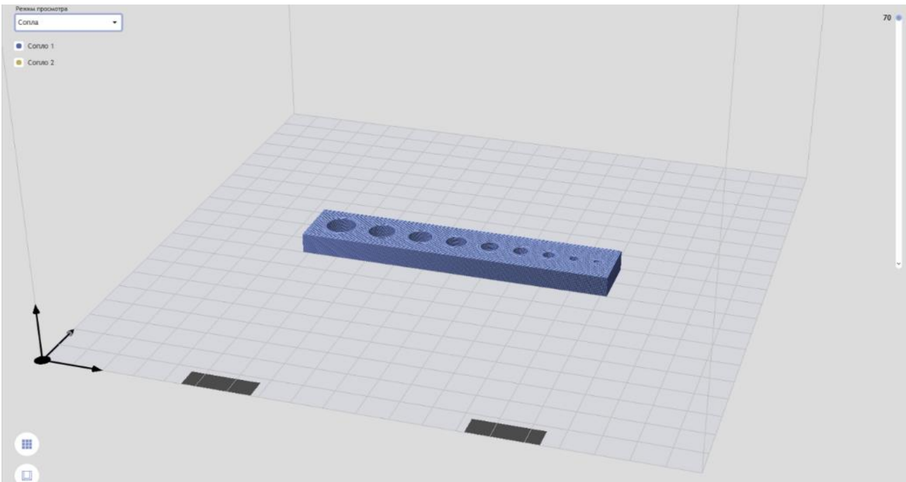

Figure 2. The part model prepared for 3D printing in the "Polygon X" software.

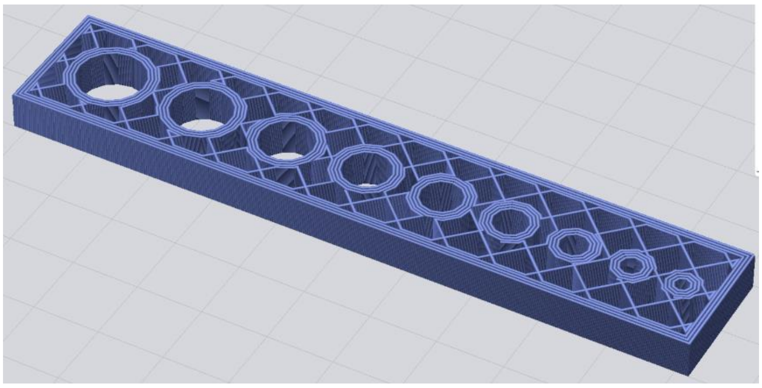

Figure 3. Detailing the quality of the part model before 3D printing.

Results and discussion

The partially printed part on the 3D printer is shown in the Fig. 4. After manufacturing the part, it was subjected to stripping operations (chamfering along the contours of the overall dimensions and in the holes). This minimized the errors in measuring the dimensions of the part with a caliper with an accuracy of 0.01 mm. Each size was measured three times to calculate the arithmetic mean.

Figure 4. The partially printed part on the 3D printer.

As a result of the measurements, the following size values were obtained:

Length: size by model – 104 mm, the actual size of the physical part – 103.8 mm, shrinkage – 0.19%;

Width: size by model – 20 mm, the actual size of the physical part – 19.92 mm, shrinkage – 0.4%;

Thickness: size by model – 7 mm, the actual size of the physical part – 6.81-6.83 mm, shrinkage – 2.43-2.71%;

Hole diameters:

size by model – Ø2 mm, the actual size of the physical part – Ø1.69 mm, shrinkage – 15.5%;

size by model – Ø3 mm, the actual size of the physical part – Ø2.61 mm, shrinkage – 13%;

size by model – Ø4 mm, the actual size of the physical part – Ø3.72 mm, shrinkage – 7%;

size by model – Ø5 mm, the actual size of the physical part – Ø4.66 mm, shrinkage – 6.8%;

size by model – Ø6 mm, the actual size of the physical part – Ø5.78 mm, shrinkage – 3.67%;

size by model – Ø7 mm, the actual size of the physical part – Ø6.74 mm, shrinkage – 3.71%;

size by model – Ø8 mm, the actual size of the physical part – Ø7.74 mm, shrinkage – 3.25%;

size by model – Ø9 mm, the actual size of the physical part – Ø8.75 mm, shrinkage – 2.78%;

size by model – Ø10 mm, the actual size of the physical part – Ø9.76 mm, shrinkage – 2.4%.

The size of the thickness of the physical part changed by 0.02 mm. The largest size was defined in the middle, the smallest to the edges of the part.

Based on the results obtained, it can be concluded that the largest shrinkage occurs in small diameter holes, and the smallest shrinkage occurs in terms of the overall dimensions of the part (length and width).

Conclusion

When manufacturing parts using 3D printing, it is necessary to take into account the shrinkage of the material after cooling. The dimensions of the electronic part model must be adjusted to obtain the required dimensions of the physical part. Experimental results show that during the application of layers, the actual thickness (height) of the part settles somewhat and a bulge forms in the middle. The larger the size of the part along the *Z* axis, the greater this deviation will be. At the same time, the remaining overall dimensions of the physical part have a shrinkage of no more than 0.5%. The greatest shrinkage of the material is observed when making holes, and depending on the size of the hole can reach 2.4-15.5%.

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STAGES OF WORK OF SUPPORT CIRCUITS OF DRAWING SYSTEMS IN FIXING AND OPERATING CONDITIONS

Abstract: *In this article explored condition in the operational is resulted results of research of the is intense-deformed condition of index contours of pendent systems in stages of prestressing of stay ropes, transition assembly. It is revealed a kind of work of mantle rings from mutual coherence of belts of stay ropes, from breakage of stay ropes or failure of sling anchorages, from a pliability of mantle rings.*

Key words: *pendent system, a stage of works, an index contour, fixing, operational conditions.*
Language: *Russian*
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СТАДИЙНОСТЬ РАБОТЫ ОПОРНЫХ КОНТУРОВ ВИСЯЧИХ СИСТЕМ В МОНТАЖНЫХ И ЭКСПЛУАТАЦИОННЫХ СОСТОЯНИЯХ

Аннотация: *Приводятся результаты исследования напряженно-деформированного состояния опорных контуров висячих систем в стадиях предварительного натяжения вант, а также в монтажных и эксплуатационных состояниях. Выявлен характер работы опорных колец от взаимной связанности поясов и от обрыва вант, отказа анкерных креплений и податливости опорных колец.*
Ключевые слова: *висячая система, стадийность работы, опорный контур, монтажные, эксплуатационные состояния.*

Введение

УДК 624.012.074

Напряженно-деформированное состояние опорных контуров висячих систем на стадиях предварительного напряжения вант, в стадиях монтажа и перехода в эксплуатационное состояние исследовались с целью:

– выявить особенности работы наружных и внутренних опорных колец в стадиях предварительного натяжения вант двухпоясных вантовых систем и перехода конструкции в монтажные и эксплуатационные состояния;

– выявить характер работы наружных и внутренних опорных колец от взаимной связанности поясов вант при различных схемах загружения;

– выявить характер работы наружных и внутренних опорных колец от обрыва поясов вант и от отказа анкерных креплений вант к кольцам покрытия;

– выявить характер работы всей пространственной системы от податливости опорных колец в горизонтальном и вертикальном направлениях;

Работа опорных контуров висячих покрытий в зависимости от вида и уровня загружения

При исследовании контурного кольца висячего покрытия при различных видах и уровнях загружения усилия в вантах как в стадии преднапряжения, так и в стадиях монтажа и эксплуатации являются внешней нагрузкой.

При этом внешняя нагрузка на контурные кольца может быть равномерно-распределенной, односторонней, местной (локальной), сосредоточенной и др., имеющей произвольный характер воздействия.

Основной особенностью опорных контуров висячих покрытий является необходимость восприятия цепных усилий от покрытия, имеющих вертикальные и горизонтальные составляющие.

Горизонтальные составляющие усилий от покрытия значительно усложняют конструкцию опорного контура, увеличивают его материало-емкость и приводят к его значительному удельному весу в технико-экономических показателях. Поэтому при проектировании сооружения необходимо стремиться к созданию наиболее благоприятных условий для работы опорных конструкций.

Для зданий круглого или эллиптического плана наилучшей и почти единственной формой опорной конструкции висячего покрытия будут железобетонные или металлические кольца, лежащие на колоннах (рис. 1). Такие кольца способны воспринимать горизонтальные составляющие цепных усилий от покрытия, локализуя их в плоскости покрытии и передавая на нижележащую конструкцию лишь вертикальные усилия. При неравномерных нагрузках на покрытие в кольце дополнительно появляются моменты.

Резюмируя рассмотрение схем опорных контурных конструкций висячих покрытий, можно отметить, что наиболее благоприятные условия для их работы создаются в замкнутых круглых кольцах, расположенных на колоннах в уровне покрытия. Такие кольца имеют наименьшие архитектурно-технологические ограничения в решениях всего здания и имеют наилучшие технико-экономические показатели. Оба эти обстоятельства обеспечили им наиболее частое применение в висячих покрытиях, особенно при больших размерах.

Из технологических соображений размеры внутренних колец висячего покрытия могут быт малыми и большими. В технической литературе покрытия, имеющие средние опорные кольца больших размеров, принято называть покрытиями с большими проемами. Наличие проемов различных размеров в основном влияет на характер распределения внешних нагрузок на покрытие. При минимальных размерах средних опорных колец нагрузка распределяется по треугольному закону. При больших размерах по трапецеидальному закону (рис. 1).

В технической литературе пока нет четкого определения для оценки размеров колец с точки зрения их влияния на работу пространственного висячего покрытия. В связи с этим будем считать, что если размер среднего кольца $r_0 = 0,05\ R_0$ – меньше 5% от радиуса наружного кольца покрытия R_0, то распределение нагрузок можно считать по треугольному закону. Здесь следует отметить, что с увеличением размера среднего кольца увеличивается его вес, который должен учитываться в виде сосредоточенной силы (массы).

В работе Л.Н.Покровского [1,2], показано, что сосредоточенную массу в динамических расчетах следует учитывать, когда сосредоточенная масса сравнима с массой всего покрытия здания.

Характер работы опорных колец зависит от взаимной связанности верхних и нижних поясов вант при различных схемах загружения (рис. 1).

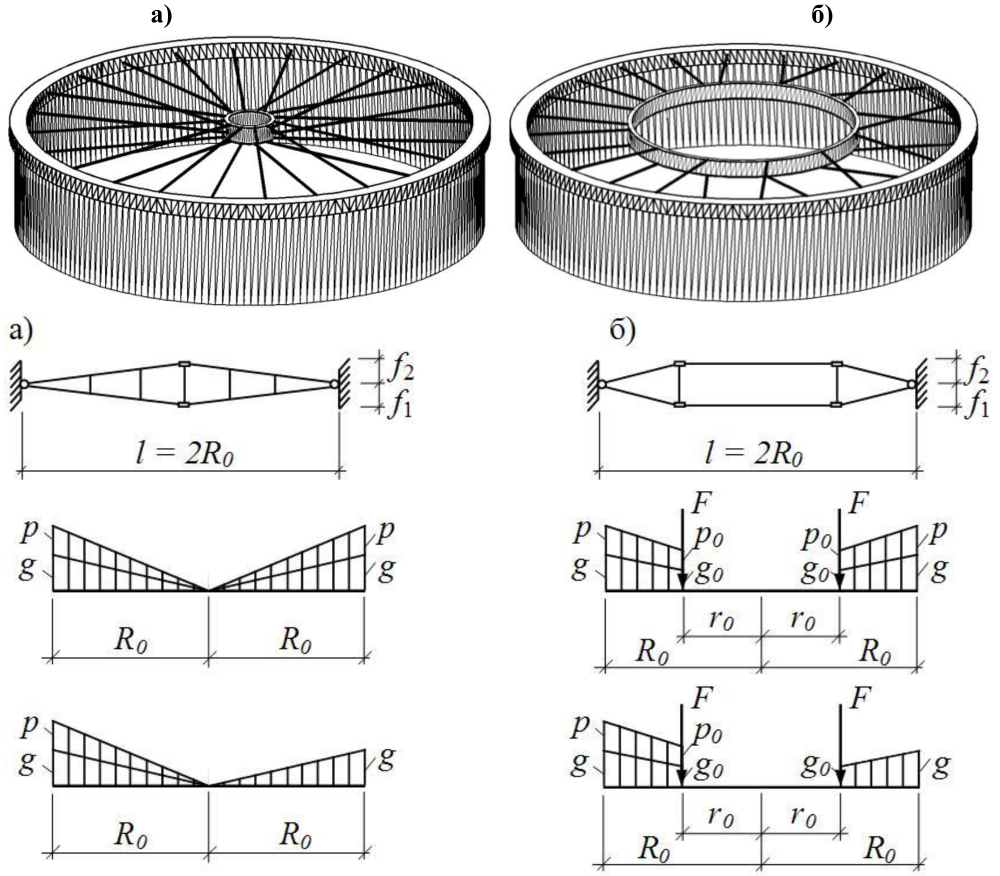

Рис. 1. Схемы загружения двухпоясных висячих покрытий с малыми (а) и с большими (б) внутренними опорными кольцами (проемами)

При связанности верхних и нижних поясов на всем протяжении пролёта покрытия (рис. 1,а) прогибы верхних и нижних поясов будут одинаковы.

Это способствует равномерному распределению горизонтального распора от поясов вант на верхние и нижние опорные кольца. При этом стабилизация покрытия от несимметричных загружений заметно повышается.

При связанности верхних и нижних поясов только в центральной зоне с помощью среднего двухпоясного кольца (барабана) (рис. 1 б), максимальный прогиб нижнего пояса вант будет равен прогибу нижнего пояса среднего кольца. При этом нижние пояса вант будут сосредоточенно загруженными от нагрузки, передающейся через средние кольца. Опорные средние кольца нижнего пояса и наружного кольца испытывают сосредоточенные загружения.

Верхний пояс вант работает аналогично, горизонтальной распор передается к внутренним и наружным кольцам равномерно. При этом прогиб пояса вант в середине пролёта будет больше, чем прогиб нижнего пояса вант.

Напряженно-деформированное состояние наружных и внутренних (контуров) колец во многом зависит от характера загружения (рис. 1,2).

В стадиях предварительного натяжения вант и равномерного загружения покрытия опорные кольца испытывают равномерное сжатие или растяжение от усилий (распоров) вант. В двухпоясных вантовых системах от усилий вант верхний пояс внутреннего кольца испытывает сжатие, нижний пояс этого кольца испытывает растяжение. При этом от усилий вант в сложном напряженно-деформированном состоянии оказывается наружное кольцо покрытия. От усилия верхнего пояса вант наружное кольцо испытывает растяжение, от усилия нижнего пояса вант испытывает сжатие. Причем через один вант усилие растяжения и сжатия чередуются равномерно. Это создает благоприятные условия работы наружного опорного кольца.

В процессе натяжения вант, перехода от монтажных состояний в эксплуатационную и в эксплуатационных стадиях от перегрузки отдельных участков висячих покрытий, могут произойти обрывы одной или нескольких вант, могут также отказаться анкерные крепления (рис. 2 г-е).

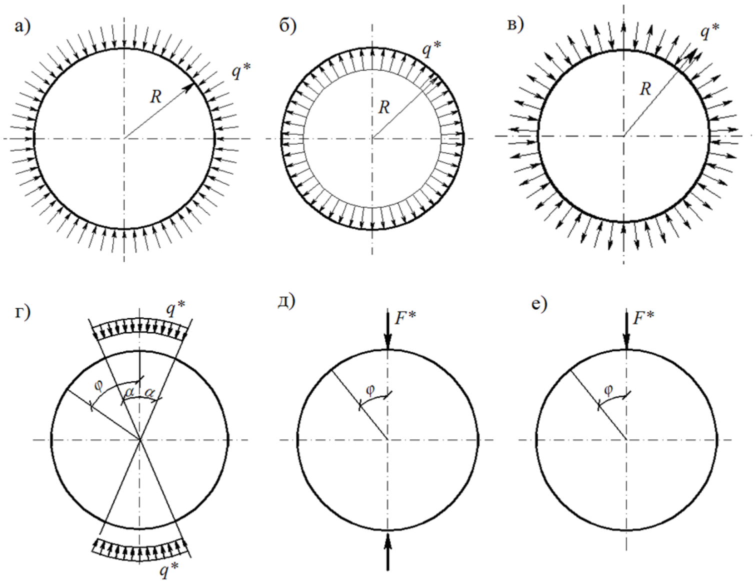

Рис. 2. Схема усилий от ванты в одно и двухпоясных кольцах при равномерно-распределенных сжимающих (а), растягивающих (б), сжимающих и растягивающих (в) локальных (г) и с осредоточенных (д,е) воздействиях.

В этом случае от внезапных усилий вант в невыгоднейшем случае отказывают контурные кольца висячих покрытий. Также при односторонних или локальных загружениях висячего покрытия в невыгоднейшем состоянии могут оказаться отдельные участки контурного кольца. Для предотвращения этих явлений контурные кольца исследуется, выявляются причины недопустимых деформированных состояний отдельных участков и будут разрабатываться специальные расчетные и конструктивные мероприятия.

Выбор сеток вантовых систем из условия благоприятных статических работ контурных колец

Из применяемых вантовых сеток можно сопоставить работу радиальной и перекрестной сеток. Принципиальное различие в работе этих сеток можно установить по благоприятному характеру работы опорных колец.

Пусть обе сетки закреплены в опорном контуре кругового очертания и имеют одинаковую стрелу провисания в центре. При действии распределенной нагрузки ванты радиальной сетки имеют поверхности вращения по кубической параболе, тогда как перекрестная сетка образует параболоид вращения второго порядка. Считая рассматриваемое положение каждой из сеток деформированным, мы вправе использовать при определении распора вант формулы для нерастяжимой нити. В радиальной системе распор одинаков:

$$H = qsR^2/6f \qquad (1)$$

где q — интенсивность нагрузки; s – шаг вант.

В перекрестной сетке в силу свойств поверхности параболоида вращения второго порядка имеем для всех вант

$$l_i^2 / f_i = const .$$

Учитывая это равенство, получим для всех вант перекрестной сетки одну и ту же величину распора

$$H = qa(2R)^2/16f = qaR^2/4f , \qquad (2)$$

где a – шаг вантовой сетки.

Вычислим теперь в единичных условиях расход материала на единицу площади каждой сетки. Приведенный расход материала составит:

для радиальной сетки

$$2CqsR^3/6fsR = CqR^2/3f , \qquad (3)$$

для перекрестной сетки

$$2Cqa^2R^2/4fa^2 = CqR^2/2f . \qquad (4)$$

Кроме того из производственных условий закрепление радиальных вант к контурным кольцам требует минимального количества анкерных креплений и снижает усилия вант, передаваемые на кольцо, в 1,5 раза

Изгибное состояние контурного кольца покрытий кругового очертания

Расчет контурного кольца вантовой системы в строгой постановке является сложной контактной задачей. Однако с достаточной точностью представляется возможным упростить учет совместной работы кольца с деформируемой вантовой сеткой.

Рассмотрим особенности расчета контурного кольца радиальной вантовой системы, как при плоской, так и при пространственной деформации.

Для оптимального состояния вантовой системы, когда контурное кольцо безмоментно, будет рассматриваться задача устойчивости; для других состояний – задача расчета на сжатие с изгибом.

Дифференциальные уравнения изгиба контурного кольца. Выберем начало оси координат. Обозначим изгибающий момент и поперечную силу, действующие в плоскости кольца, через M_1 и Q_1 то же, из плоскости - через M_2 и Q_2, крутящий момент и продольную силу — соответственно через M_{12} и N.

Выделив бесконечно малый элемент кольца длиной ds, составим уравнения равновесия его в деформированном состоянии:

$$\begin{cases} Q_1' + \dfrac{N}{\rho_1} + q_n = 0, \\ N' - \dfrac{Q_1}{\rho_1} + q_t = 0, \\ M' - Q_1 = 0; \end{cases} \quad \begin{cases} Q'_2 + \dfrac{N}{\rho_2} + q_в = 0, \\ M'_2 + \dfrac{M_{12}}{\rho_1} - Q_2 = 0, \\ M'_{12} - \dfrac{M_2}{\rho_1} = 0. \end{cases} \qquad (5)$$

Здесь q_n, q_t, q_b – компоненты внешней погонной нагрузки контурного кольца; ρ_1, и ρ_2 – радиусы кривизны деформированной оси, а которые выражаются через приращения кривизн, χ_1 и χ_2 следующим образом:

$$\rho_1 = \frac{1}{\dfrac{1}{\rho} + \chi_1} \approx \rho(1 - \chi_1\rho), \quad \rho_2 = \frac{1}{\chi_2}.$$

Геометрические соотношения, связывающие линейные и угловые перемещения с деформациями, имеют вид:

$$w' = \frac{u}{\rho}, \ \theta_y = u' + \frac{w}{\rho}, \ \chi_1 = \theta_y, \ \theta_x = \upsilon' + \frac{w}{\rho},$$

$$\chi_1 = \theta_x + \frac{\theta_z}{\rho}, \ \tau = \theta'_x + \frac{\theta_x}{\rho} \qquad (6)$$

Здесь u, υ и w – компоненты перемещения оси кольца вдоль x, y и z;

θ_x, θ_y и θ_z – углы поворота относительно тех же осей; τ – угол кручения.

Зависимость внутренних усилий кольца от деформаций вант имеет для стержни малой кривизны такой же вид, как для прямоугольного стержня:

$$M_1 = -EJ_1\chi_1 = -A\chi_1;$$
$$M_2 = -EJ_2\chi_2 = -B\chi_2;$$
$$M_{12} = -GJ_d\tau = -C\tau, \qquad (7)$$

где $C = -GJ_d$ – жесткость стержня при кручений.

Отметим, что при достаточно большой гибкости и частом расположении колонн их влияние на работу кольца в своей плоскости также сводится к введению упругого основания винклеровского типа.

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Issue Article

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CALCULATION OF HANGING SHELLS COMPLEX GEOMETRY

Abstract: *A method for calculating large-span, spatial hanging shells is presented. A resolving system of equations is obtained for determining the stress-strain state of the hanging shells, the support contour, bearing and stabilizing cables.*

Key words: *fracturing system, calculation, hanging shells, complex geometries, bearing, stabilizing cables.*
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РАСЧЕТ ОРТОГОНАЛЬНЫХ ВИСЯЧИХ СИСТЕМ СЛОЖНОЙ ГЕОМЕТРИИ

Аннотация: *Приводится методика расчета большепролетных, пространственных висячих оболочек сложной геометрии. Получены разрешающие система уравнений для определения напряженно-деформированного состояния висячих оболочек, опорного контура, несущих и стабилизирующих вант.*

Ключевые слова: *разрешающая система, расчет, висячий оболочки, сложной геометрии, несущие, стабилизирующие ванты.*

Введение

УДК 624.012.074

Вантовые системы, образуемые взаимно перекрещивающимися тросами, называются сетями. Применяются сети ортогональные, ромбические геодезические и др., при этом ванты могут опираться на жесткий деформируемый контур.

Рассмотрим висячих оболочечных систем – ортогональные сети, опертые на двух жестких замкнутых криволинейных контурных арок (рис.1). Ортогональными называют сети из двух семейств вант, расположенные в плане параллельно, направленных взаимно перпендикулярно.

Одно семейство вант имеет провес вниз (несущие), другое — выпуклость вверх (стабилизирующие). Предварительное напряжение системы создается натяжением стабилизирующих вант. Все ванты одного семейства расположены с одинаковым шагом в параллельных вертикальных плоскостях. При равномерно распределенной нагрузке на покрытие параллельно расположенные пологие ванты получают форму конгруэнтных парабол, отличающихся только ординатой вершин, имея уравнение поверхности гиперболического параболоида:

$$z = -4fx^2/l_н^2 + 4f_c y^2/l_c^2, \quad (1)$$

где в дальнейшем, индекс «н» соответствует несущим, а индекс «с» – стабилизирующим вантам.

Расчет сложную висячую систему выполним, принимая за исходное состояние покрытие при действие полной расчетной нагрузки. По теории висячих систем исследованиями В. К. Качурина [1] установлено, что поверхность ортогональной системы после изменения нагрузки несколько отличающееся от поверхности гиперболического параболоида. Кривые провисания вант отличаются от парабол, а нагрузка, передаваемая стабилизирующими вантами на несущие, несколько отличается от равномерно распределенной.

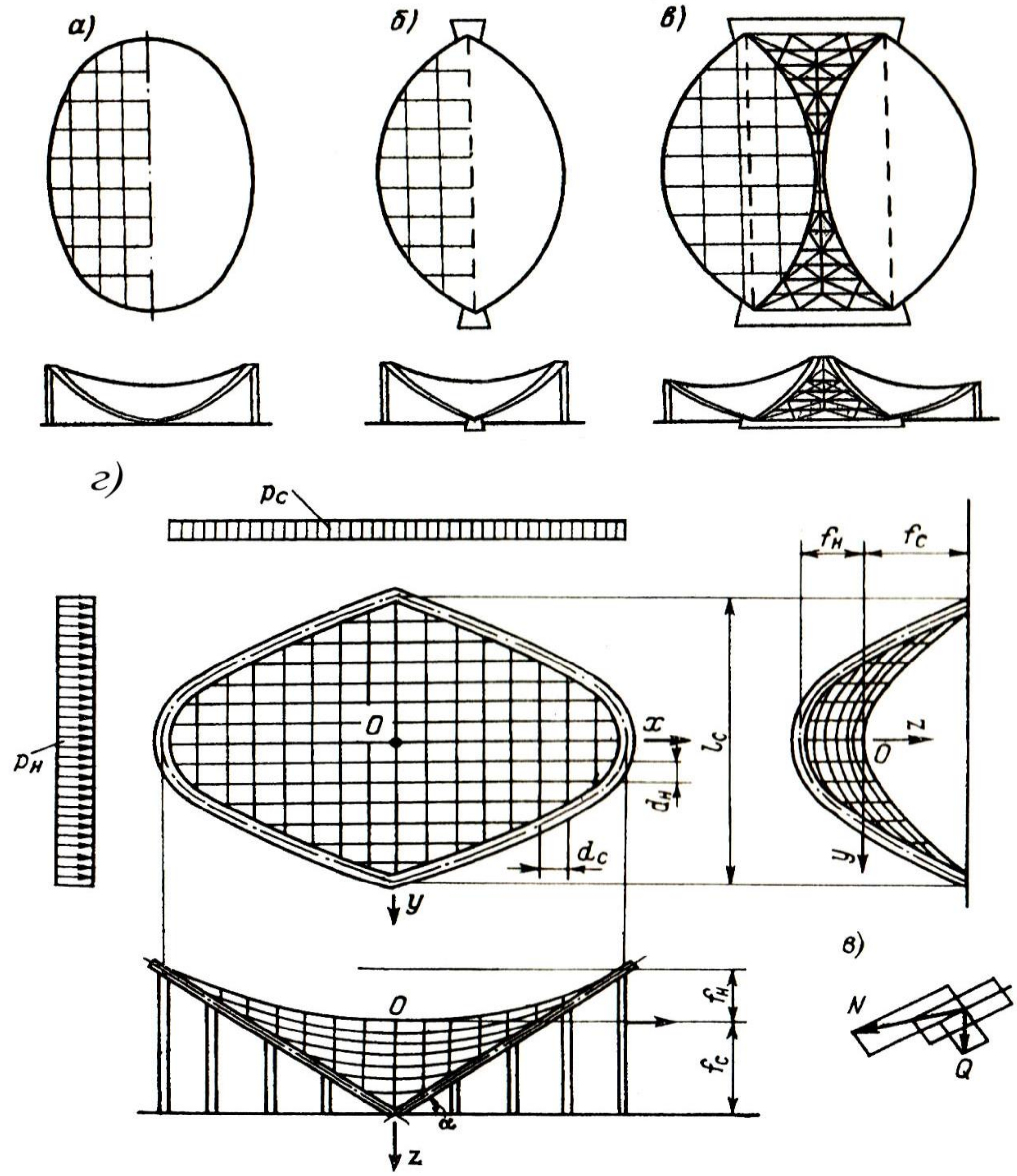

Рис.1. Ортогональные висячие системы сложный геометрии:
а – с эллиптическим опорным контуром; б – г, с контуром в виде двух плоских арок;

Рассмотрим систему с двумя эллиптическим арочным опорным контуром (рис.1 а). Так как все параболы одного семейства конгруэнтны, то распоры в них от одинаковой равномерной нагрузки равны между собой.

Реакция одного семейства вант, передающаяся на опорный контур может принята в виде равномерно распределенной погонной нагрузки

$$p_н = H_н / d_н \text{ и } p_c = H_c / d_c \quad (2)$$

Уравнение эллипсовидного контура имеет вид

$$4x^2 / l_н^2 + 4y^2 / l_c^2 = 1 \quad (3)$$

В расчете сети предполагается, что ванты упругие, а контур – абсолютно жесткий.

Ванты несут полную расчетную нагрузку от покрытия и дополнительную нагрузку от натяжения стабилизирующих вант в размере 10—15% от этой нагрузки. Для исходного состояния системы провесы главных тросов $f_н$ и f_c будем считать заданными. Усилия в главной несущей и стабилизирующей вантах, а следовательно, и во всех других случаях могут быть определены

$$H_н = q_н d_н l_н^2 / (8 f_н) \text{ и } H_c = q_c d_c l_c^2 / (8 f_c). \quad (4)$$

В ходе дальнейшего расчета определяется сечение несущих вант и выполняется проверки.

Сечение стабилизирующих вант задаются в следующих пределах:

$$\omega_c = (0,2 \div 0,4)\omega_н d_c / d_н , \quad (5)$$

где $\omega_c = A_c/E_c$, $\omega_н = A_н/E_н$ - жесткости стабилизирующего и несущего ванта; A_c, и $A_н$ - площади их по перечного сечения; E_c и $E_н$ - модуль упругости.

За исходное состояние системы принимают вантовая сеть без нагрузки собственным весом, пренебрегают либо нагрузку ее весом, незамоноличенных плит в сочетании с ветровым отсосом.

Рассмотрим условие равновесия вантовой сети при снятии части нагрузки

$$q_н + q_1 + q_c , \quad (6)$$

где q_1 - внешняя нагрузка в новом состоянии системы, а $q_н$ и q_c - нагрузки, воспринимаемые вантами соответствующих направлений.

Значение нагрузки на ванту получим как произведение распора на провес ванты. Распор несущей ванты при снятии части нагрузки уменьшится, так же как ее провес:

$$q_н = 8M_н / (d_н l_н^2) = 8(H_н - \Delta H_н)(f_н - x) / (d_н l_н^2) \quad (7)$$

Аналогично

$$q_c = 8(H_c - \Delta H_c)(f_c + x) / (d_c l_c^2) , \quad (8)$$

где $x = \Delta f_н = \Delta f_c$ неизвестное приращение провеса. Приращение распоров $\Delta H_н$ и ΔH_c определим по формулам

$$\Delta H_н = 8\omega_н (2 f_н - x) x / (3 l_н^2 m_н^2) . \quad (9)$$

$$\Delta H_c = 8\omega_c (2 f_c + x) x / (3 l_c^2 m_c^2) . \quad (10)$$

Подставим полученные выражения (9) и (10) в формулы (7) и (8) а затем в (6). В результате получим решение в виде кубического уравнения относительно приращения провеса:

$$(B_{1н} + B_{1c}) x^3 - 3(B_{1н} f_н + B_{1c} f_c) x^2 + (A_{1н} + A_{1c} + 2B_{1н} f_н^2 + B_{1c} f_c^2) x - (q - q_1) = 0 \quad (11)$$

где $A_{1н} = 8H_н / (d_н l_н^2)$; $A_{1c} = 8H_c / (d_c l_c^2)$; $B_{1н} = 64\omega_н / (3 l_н^4 d_н m_н^3)$; $B_{1c} = 64\omega_c / (3 l_c^4 d_c m_c^3)$; q - полная нагрузка исходного состояния; $m = S_н/l_н$, $m = S_c/l_c$ - отношение длины вант к их пролету соответствующих направлений вант.

Рассмотрим систему, приведенную на рис. 1 в,г. Сеть как и ранее, имеет поверхность гиперболического параболоида и оперта на две плоские наклонные арки параболического очертания.

Очертания контура надо выбирать так, чтобы в плане не возникали изгибающие моменты, т. е, контур был бсзмоментным. Как показано в работе [3-5] наиболее выгодным является эллипсовидный контур (рис.1а), причем условие его безмоментности имеет вид

$$q_c = q / (f_н f_c - 1) \quad (12)$$

или

$$q_н = q[1 + f_c / (f_н - f_c]. \quad (13)$$

Условие безмоментности контура может быть достигнуто выбором провесов главных вант и соотношением нагрузок, приходящихся на несущие и стабилизирующие ванты, только при определенной нагрузке, ее изменении меняют провесы вант и безмоментное состояние контура нарушается.

Безмоментное состояние контура выгодно подобрать для нагрузки, между постоянной и максимальной, половины снеговой нагрузки. При этом моменты в контуре возникают как при отсутствии снега, так и при полном снеге, однако по абсолютной величине оказываются минимальными.

В расчет изгиба контура на действие равномерно распределенных нагрузок удобно вести методом сил. Замкнутое кольцо трижды статически неопределимо. Введя шарниры в двух диаметрально противоположных сечениях, превратим его в статически определимое (рис. 1а). По условиям симметрии третье неизвестное – перерезывающие силы в шарнирах – обращается в нуль, а нормальные давления – в $p_c l_н/2$. Неизвестные моменты в шарнирах также равны между собой. Решение системы сводится к одному уравнению метода сил с одним неизвестным – изгибающими моментами, в шарнирах. Максимальные по абсолютной величине изгибающие моменты в контурном кольце возникают в сечениях, расположенных на главных осях эллипса.

Уравнение плоскости, в которой лежит арка:

$$Z = 2(f_н - f_c/(l_н - f_c) \quad (14)$$

Получим уравнение оси арки относительно центра сети. Решая это выражение совместно с (1), преобразуя его так, чтобы начало координат лежало в ключе арки, а ось *x* была направлена по оси ее симметрии, тогда уравнение оси арки примет вид

$$2f_н \cos^2\alpha x^2/l_н + (4f_н \cos^2\alpha^2/l_н - \sin\alpha)x = 4f_c y_c^2 2/l^2 \quad (15)$$

Если в этом выражении положить

$$2x\cos\alpha x/l_н = \eta; \quad 2y/l_c = \xi \quad и \quad f_н/f_c = \lambda \quad (16)$$

то оно примет вид $\lambda\eta^2 + (1-\lambda)\eta = \xi^2$,

где ξ имеет действительные значения при $1+\lambda(\eta-1) \ge 0$.

Так как η изменяется в пределах от нуля до единицы, то при $\eta \to 0$ условие действительности обращается в $\lambda \le 1$ или $f_н \le f_c$.

Для облегчения вычисления коэффициентов при неизвестных свободных членов канонических уравнений определим изгибающие моменты в любом сечении контурной арки в основной системе.

Расчет сети выполнен так же, как и в предыдущем случае. Контурные арки рассчитываются на действие равномерно распределенных нагрузок $p_н$ и p_c. Нагрузки от вант раскладываются на две составляющие – одна в плоскости опорной арки, другая – нормально к ней (рис. 1,в).

Очертание арки должно быть выбрано так, чтобы по всей длине пересекаться с поверхностью сети согласно выражению (1).

Условие это несовместимо с условием безмоментности контура (12). Действительно, если q_c составляет 10-20% от *q*, то на основании (12) λ = 5÷10. Очевидно, что контурные арки существенно моментны.

Определение усилий, действующих в контурных арках, может быть выполнено методом сил. При этом в качестве основной системы удобно рассматривать трехшарнирные арки, вводя шарниры на главных осях контура.

Так как усилия в противоположных шарнирах при равномерной нагрузке попарно равны, то задача решается системой из двух канонических уравнений.

Для облегчения вычисления коэффициентов при неизвестных и свободных членов канонических уравнений определим изгибающие моменты в любом сечении контурной арки в основной системе.

Из условии равновесия полуарки нормальное усилие в ключевом шарнире

$$N_ш = p_н l_н^2 \cos\alpha(4l_c) + p_c l_c^2/(4\cos\alpha) \quad (17)$$

Усилия, действующие в плоскости арки:

$$p_н = q_н l_н^2 \cos\alpha/8f_н \quad (18)$$

$$p_c = q_c l_c^2 \cos\alpha/8f_c$$

Изгибающий момент в арке для точки с координатами *(x, y)*

$$M_x = N_ш x - p_н y^2/2 - p_c x^2/2$$

Подставив в эту формулу значение $N_ш$ и произведя все необходимые упрощения и переходя к обобщенным координатам η и ξ, получим

$$M_x = l_н^2 l_c^2 (q_н \cos\alpha + q_c \cos\alpha)(1(4l_c) + p_c l_c^2/(4\cos\alpha) \quad (19)$$

В опорном шарнире арки от единичного момента

$$M_1 = \eta \quad (20)$$

То же, в ключевом шарнире от момента:

$$M_1 = (1-\eta) \quad (21)$$

Наклон арки и провесы тросов выгодно подобрать так, чтобы составляющие усилий *N*, направленные вверх нормально к плоскости арки, уравновешивались составляющей ее веса *Q*. Тогда арки работают только в своей плоскости, а поддерживающие их стойки включаются в работу лишь при изменении нагрузки. Кроме изложенного расчета на равномерно распределенную нагрузку, существуют другие методы, позволяющие рассчитать систему на более сложные виды нагрузок, например на неравномерную снеговую нагрузку.

Нелинейную задачу расчета системы можно заменить линейной, ввести одну поправку, учитывающую удлинение, затем вторую и так далее, до тех пор, пока не будет получена удовлетворительная сходимость результатов.

Применение метода последовательных приближений к расчету сетей приводит к решению значительного количества систем линейных уравнений с большим числом членов и может быть осуществлено только на компьютере.

Решение системы нелинейных уравнений может быть также заменено рекуррентной последовательностью линейных уравнений с меняющимися коэффициентами, когда нагрузка прикладывается к системе малыми порциями решая систему линейных уравнений и пологая при этом каждое предыдущее состояние за исходное.

Рассмотрим расчет висячей оболочки на температурные воздействия.

Определим усилия в сети при изменении температуры на $\Delta t = (t - t_1)$, считая, что провесы главных вант и действующие в них до изменения температуры усилия известны. Положим, что при уменьшении температуры провес главной несущей ванты уменьшится на величину *x(t)* а провес главной стабилизирующей ванты возрастет на ту же величину. Распоры вант обоих направлений при уменьшении температуры увеличатся.

Так мак относительное укорочение всех вант одного направления одинаково, одинаковым будет и приращение распоров в них, что можно рассматривать и как результат приращения нагрузки.

Уравнение равновесия по аналогии с предыдущим имеет вид (6) а значения нагрузок:

$$\left.\begin{aligned} q_н &= 8(H_н - \Delta H_н)(f_н - x(t)/(d_н l_н^2); \\ q_c &= 8(H_c - \Delta H_c)(f_c - x(t)/(d_c l_c^2), \end{aligned}\right\} \qquad (22)$$

где x – приращение провеса главных вант, от влияния температуры;

По условиям равновесия до изменения температуры

$$8H_н f_н/(d_н l_н^2) = q + 8H_c f_c/(d_c l_c^2).$$

Тогда при подстановке уравнения (22) в (6) имеем

$$\left[\Delta H_н(f_н - x(t) - H_н x(t)\right]/(d_н l_н^2) = \left[\Delta H_c(f_c + x(t) - H_c x(t)\right]/(d_c l_c^2) \qquad (23)$$

При уменьшении температуры на Δt и коэффициенте линейного расширения η удлинение тросов

$$\Delta S = \Delta HmS/\omega - \eta\Delta tS$$

На основании уравнения ( )

$$\Delta S_н = -8x(t)[2f_н - x(t)]/(3l_н);$$

$$\Delta S_c = 8x(t)[2f_c + x(t)]/(3l_c).$$

Приравнивая друг к другу правые части этих выражений, вычислим приращение распоров:

$$\left.\begin{aligned} \Delta H_н &= -8\omega_н[2f_н - x(t)]x(t)/(3S_н^2) + \eta\Delta t\omega_н/m_н; \\ \Delta H_c &= 8\omega_c[2f_c - x(t)]x(t)/(3S_c^2) + \eta\Delta t\omega_c/m_c. \end{aligned}\right\} \qquad (24)$$

Подставив в формулу (23) значения $\Delta H_н$ и ΔH_c из (24) получим кубическое уравнение относительно приращения провеса

$$\begin{aligned} &(B_{1н} - B_{1c})[x(t)]^3/8 - (B_{1н}f_н - B_{1c}f_c)3x^2/8 + [B_{1н}f_н^2/4 + B_{1c}f_c^2/4 + \\ &+ C_н + C_c + H_н/(d_н l_н^2) + H_c/(d_c l_c^2)]x - (C_н f_н - C_c f_c) = 0, \end{aligned} \qquad (25)$$

где $C_н = \eta\Delta t\omega_н/(d_н l_н^2 m_н)$ и $C_c = \eta\Delta t\omega_c/(d_c l_c^2 m_c)$; $B_{1н}$ и B_{1c} приняты по (11).

При возрастании температуры в системе выражение (25) приобретает вид

$$\begin{aligned} &(B_{1н} - B_{1c})[x(t)]^3/8 - (B_{1н}f_н - B_{1c}f_c)3[x(t)]^2/8 + [B_{1н}f_н^2/4 + B_{1c}f_c^2/4 - \\ &- C_н + C_c + H_н/(d_н l_н^2) + H_c/(d_c l_c^2)]x(t) - (C_н f_н - C_c f_c). \end{aligned} \qquad (26)$$

Приведенная расчетная методика позволяет запроектировать большепролетные висячие уникальные сооружения на климатические и температурные воздействие.

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Issue Article

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FINDING AN EXPLICIT SOLUTION OF THE FREDHOLM EQUATION OF 2ND FORM IN MAPLE

Abstract: *The theory of integral equations acts as a mathematical tool for solving various problems of mathematical modeling. The modern mathematical packages application, the dynamic development of which at the present stage is carried out successfully, creates an opportunity to simplify considerably the algorithms drawing up and to develop mathematical programs of finding the solution of integral equations at modeling of physical processes and phenomena. The article describes the development of a code for finding an explicit solution of the Fredholm integral equation of the 2nd form with a degenerate core. The method of reduction to a system of linear algebraic equations using the criterion of degeneracy of the kernel is realized.*

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Introduction

Many problems of mathematical physics are reduced to linear integral equations of the form:

$$\lambda\int_a^b K(x,t)\varphi(t)dt = f(x), a\le x\le b \quad (1)$$

$$\varphi(x)-\lambda\int_a^b K(x,t)\varphi(t)dt = f(x), a\le x\le b \quad (2)$$

concerning the unknown function $\varphi(x)$,which are called Fredholm integral equations of the 1st and 2nd kind, respectively.[1]

Here we consider a linear Fredholm equation of the 2nd form:

$$\varphi(x)-\lambda\int_a^b K(x,t)\varphi(t)dt = f(x),\ a\le x\le b, \quad (3)$$

where $K(x,t)$ is degenerate kernel.

One of the methods of finding the solution of equation (3) in explicit form is the method of reducing the original integral equation to a system of linear algebraic equations. According to the definition of the degenerate kernel, $K(x,t)$ can be represented as a finite sum of the product of functions, each of which depends on only one variable:

$$K(x,t)=\sum_{i=1}^{N} p_i(x)q_i(t), \qquad (4)$$

where each of the functions $\alpha_i(t)$, $\beta_i(t)$ are linearly independent. [2]Substituting (4) into (3), the equation takes the form:

$$\varphi(x)-\lambda\sum_{i=1}^{N} p_i(x)\int_a^b q_i(t)\varphi(t)dt = f(x).$$

Taking $C_i=\int_a^b \beta_i(t)\varphi(t)dt$, the equation is written:

$$\varphi(x)-\lambda\sum_{i=1}^{N} C_i\alpha_i(x)= f(x). \qquad (5)$$

Whence the solution of equation (3) will be represented by this formula:

$$\varphi(x)= f(x)+\lambda\sum_{i=1}^{N} C_i\alpha_i(x). \qquad (6)$$

To find the coefficients C_i, multiply equation (3) by the function $q_k(x)$ and then integrate the obtained expression within the range from a to b. As a result of these steps, equation (3) has the following form:

$$\int_a^b q_k(x)\varphi(x)dx-\lambda\sum_{i=1}^{N} C_i\int_a^b \alpha_i(x)q_k(x)\varphi(x)dx=\int_a^b f(x)q_k(x)\,dx. \qquad (7)$$

Using the notations for the integrals in (7):

$$C_k=\int_a^b f(x)q_k(x)\,dx,\ \alpha_{ik}=\int_a^b p_i(x)q_k(x)\,dx,\ f_{ik}=\int_a^b f(x)q_k(x)\,dx, \qquad (8)$$

the last expression will have the form [3], [4]:

$$C_k-\lambda\sum_{i=1}^{N} C_i\alpha_{ik} = f_k,\ k=\overline{1,N}. \qquad (9)$$

Thus, we obtain the set of equations (9), which is defined as a system of n linear equations with respect to n unknowns C_i with matrix [5]:

$$A_\lambda=\begin{pmatrix} 1-\lambda\alpha_{11} & -\lambda\alpha_{21} & \dots & -\lambda\alpha_{N1} \\ -\lambda\alpha_{12} & 1-\lambda\alpha_{22} & \dots & -\lambda\alpha_{N2} \\ \dots & \dots & \dots & \dots \\ -\lambda\alpha_{1N} & -\lambda\alpha_{2N} & \dots & 1-\lambda\alpha_{NN} \end{pmatrix}$$

If λ in equation(3) is not the same as any of the roots of the equation:

$$D(\lambda)=\det A_\lambda=\begin{vmatrix} 1-\lambda\alpha_{11} & -\lambda\alpha_{21} & \dots & -\lambda\alpha_{N1} \\ -\lambda\alpha_{12} & 1-\lambda\alpha_{22} & \dots & -\lambda\alpha_{N2} \\ \dots & \dots & \dots & \dots \\ -\lambda\alpha_{1N} & -\lambda\alpha_{2N} & \dots & 1-\lambda\alpha_{NN} \end{vmatrix}=0, \qquad (10)$$

namely $\lambda\neq\lambda_s, s=\overline{1,n}$ -system has a solution and

$$C_i=\frac{D_i(\lambda)}{D(\lambda)},\ i=\overline{1,N}, \qquad (11)$$

where the determinants $D_i(\lambda)$ are obtained from the determinant $D(\lambda)$ by replacing the i - column by the column of free terms $(f_1 \quad f_2 \quad \dots \quad f_N)^T$:

$$D_i(\lambda)=\begin{vmatrix} 1-\lambda\alpha_{11} & -\lambda\alpha_{21} & \ldots f_1\ldots & -\lambda\alpha_{N1} \\ -\lambda\alpha_{12} & 1-\lambda\alpha_{22} & \ldots f_2\ldots & -\lambda\alpha_{N2} \\ \ldots & \ldots & \ldots & \ldots \\ -\lambda\alpha_{1N} & -\lambda\alpha_{2N} & \ldots f_N\ldots & 1-\lambda\alpha_{NN} \end{vmatrix}.$$

Substituting the values of C_i by (11), the solution of equation (3) can be written in the form:

$$\varphi(x)=f(x)+\lambda\sum_{i=1}^{N}\frac{D_i(\lambda)}{D(\lambda)}\alpha_i(x). \qquad (12)$$

If λ in equation (3) coincides with one of the roots of equation (12): : $\lambda=\lambda_s$, which means, $D(\lambda)=0$ - the system (9) is insolvable at arbitrary right-hand sides. Therefore, integral equation (3) is insoluble at arbitrary function $f(x)$.[3]

If $D_i(\lambda_s)=0$, $D(\lambda_s)=0$, then system (9) has infinitely many solutions. The integral equation (3) will also have infinitely many solutions.[3]

An alternative method of finding a solution to equation (3) is implemented in the computer mathematics system Maple.[7] Let us implement the solution algorithm and find a solution to the Fredholm equation of the 2nd form:

$$\varphi(x)-\int_a^b(3x+2t)\varphi(t)dt=8x^2-5x,\ 0\le x\le 1$$

Calculations are performed in the *Student* package. [8] Enter the original equation:

```
restart; with(Student[Calculus1]);
eq1 := phi(x) = 8·x^2 − 5·x + int((3·x + 2·t)·phi(t), t = 0..1);
```

$$eq1 := \phi(x)=8x^2-5x+\int_0^1(3x+2t)\,\phi(t)\,dt$$

Let us rewrite the equation in the form:

```
phi(x) = 8·x^2 − 5·x + 3·x·int(phi(t), t = 0..1) + 2·int(t·phi(t), t = 0..1);
```

$$\phi(x)=8x^2-5x+3x\left(\int_0^1\phi(t)\,dt\right)+2\left(\int_0^1 t\,\phi(t)\,dt\right)$$

We insert the notations $C1=\int_0^1\varphi(t)dt$, $C2=\int_0^1 t\varphi(t)dt$, according to which the solution of Equation $\varphi(x)$ will be written in the formula:

```
sol := subs(int(phi(t), t = 0..1) = C1, int(t·phi(t), t = 0..1) = C2, %);
```

$$sol := \phi(x)=3\,C1\,x+8x^2+2\,C2-5x$$

We integrate the last equation [7]:

```
e1 := int(lhs(sol), x = 0..1) = rhs(Rule['+'](Int(rhs(sol), x = 0..1)));
```

$$e1 := \int_0^1\phi(x)\,dx=\int_0^1 3x\,C1\,dx+\int_0^1 8x^2\,dx+\int_0^1 2\,C2\,dx+\int_0^1(-5x)\,dx$$

We multiply the integrated expression $e1$ by x and integrate again in the range from to [7]:

$$e2 := int(x \cdot lhs(sol), x = 0..1) = rhs(Rule['+'](Int(expand(x \cdot rhs(sol)), x = 0..1)));$$

$$e2 := \int_0^1 x\,\phi(x)\,dx = \int_0^1 3\,C1\,x^2\,dx + \int_0^1 8\,x^3\,dx + \int_0^1 2\,C2\,x\,dx + \int_0^1 (-5\,x^2)\,dx$$

We make a system of algebraic equations to find the constants $C1$, $C2$:

$$e11 := subs(int(\text{phi}(x), x = 0..1) = C1, lhs(e1)) = value(rhs(e1));$$
$$e22 := subs(int(x \cdot \text{phi}(x), x = 0..1) = C2, lhs(e2)) = value(rhs(e2));$$

$$e11 := C1 = \frac{3}{2}\,C1 + \frac{1}{6} + 2\,C2$$

$$e22 := C2 = C1 + \frac{1}{3} + C2$$

Here we find the solution of the system:

$$res := solve(\{e11, e22\}, \{C1, C2\});\ assign(res);$$

$$res := \left\{C1 = -\frac{1}{3}, C2 = 0\right\}$$

Let's write down the solution of the initial equation:

sol;

$$sol;\quad \phi(x) = 8\,x^2 - 6\,x$$

Let's check the found solution:

$$simplify(lhs(eq1) - rhs(eq1));$$

$$0$$

Let us consider the reduction to a system of linear algebraic equations the Fredholm integral equation of the 2nd kind , determining directly the coefficients α_{ik} and f_k in formula (9) for C_k by formulae (8) on the example of Eq.:

$$\varphi(x) - \int_a^b (3x + 2t)\varphi(t)\,dt = 8x^2 - 5x\,.$$

The kernel $K(x,t) = 3x + 2t$ by definition of degeneracy of the kernel is represented in the form (4)[]:

$$K(x,t) = \sum_{i=1}^{2} p_i(x)q_i(t) = p_1(x)q_1(t) + p_2(x)q_2(t)\,, \qquad (13)$$

where $p_1(x) = x$, $q_1(t) = 3$, $p_2(x) = 2$, $q_2(t) = t$.

Then by formulas (8) we calculate a_{11}, a_{12}, a_{21}, a_{22}, f_1, f_2:

$$a_{11} = \int_0^1 p_1(t)q_1(t)dt\,;\ a_{12} = \int_0^1 p_2(t)q_1(t)dt\,;\ a_{21} = \int_0^1 p_1(t)q_2(t)dt\,;\ a_{22} = \int_0^1 p_2(t)q_2(t)dt$$

$$f_1 = \int_0^1 q_1(t)f(t)dt\,;\ f_2 = \int_0^1 q_2(t)f(t)dt\,.$$

Let us perform the calculations in Maple[8]-[9] environment:

```
p1x := x; q1t := 3; p2x := 2; q2t := t ; fx := 8·x^2 − 5·x;
fr := fx + lambda·(C1·(p1x) + C2·(p2x));
a11 := int((subs(x = t, p1x))·q1t, t = 0 ..1);
a12 := int((subs(x = t, p2x))·q1t, t = 0 ..1);
a21 := int((subs(x = t, p1x))·q2t, t = 0 ..1);
a22 := int((subs(x = t, p2x))·q2t, t = 0 ..1);
f1 := int((subs(x = t, fx))·q1t, t = 0 ..1);
f2 := int((subs(x = t, fx))·q2t, t = 0 ..1);
```

$$p1x := x$$
$$q1t := 3$$
$$p2x := 2$$
$$q2t := t$$
$$fx := 8x^2 - 5x$$
$$fr := 8x^2 + x\,C1 - 5x + 2\,C2$$
$$a11 := \frac{3}{2}$$
$$a12 := 6$$
$$a21 := \frac{1}{3}$$
$$a22 := 1$$
$$f1 := \frac{1}{2}$$
$$f2 := \frac{1}{3}$$

Let us make a system to calculate the constants $C1$, $C2$ (in the system denoted by $C11, C22$, respectively) and find its solution:

```
s := ({C11 − (a11·C11 + a12·C22) = f1, C22 − (a21·C11 + a22·C22) = f2});
rs := solve(s, {C11, C22}); assign(rs);
```

$$s := \left\{-\frac{1}{3}\,C11 = \frac{1}{3},\ -\frac{1}{2}\,C11 - 6\,C22 = \frac{1}{2}\right\}$$
$$rs := \{C11 = -1,\ C22 = 0\}$$

Substituting the values of $C11$ and $C22$ with the subs command, the solution of the equation is written:

```
req := subs(C1 = C11 , C2 = C22, fr);
```

$$req := 8x^2 - 6x\ .$$

For the complete solution of the integral equation, both in the first and in the second case, the analytical study of the degeneracy of the kernel $K(x,t)$ was not carried out: the degeneracy of the kernel was accepted as a fact. In order that the mathematical realization of the validity of finding the solution of the equation is carried out, we use the criterion of degeneracy of the kernel of the integral equation.[10]. The wording of the criterion is as follows "For the kernel $K(x,t)$ to be degenerate it is necessary and enough that $\det A_n[K](x,t) \neq 0$, $\det A_m[K](x,t) = 0$, for $\forall m > n$, where the matrix $A_m[K](x,t)$ is of the form:

$$A_m[K](x,t)=\begin{pmatrix} K & K'_x & \dots & K^{(m-1)}_{x^{(m-1)}} \\ K'_y & K''_{xy} & \dots & K^{(m)}_{x^{(m1)}y} \\ \dots & \dots & \dots & \dots \\ K^{(m-1)}_{y^{(m-1)}} & K^{(m)}_{xy^{(m1)}} & \dots & K^{(2m-2)}_{x^{(m1)}y^{(m-1)}} \end{pmatrix} »[10] \qquad (13)$$

Let us realize the criterion for the kernel $K(x,t)=3x+2t$. We construct the matrices $A_2[K](x,t)$and $A_3[K](x,t)$, by computing the coefficients, according to (13), then calculate the values of the determinants $A_2[K](x,t)$ и $A_3[K](x,t)$[8]-[9]:

$k11 := Kxt; k12 := diff(Kxt, x\$1); k13 := diff(Kxt, x\$2);$
$k21 := diff(Kxt, t\$1); k22 := diff(Kxt, x\$1, t\$1); k23 := diff(Kxt, x\$2, t\$1);$
$k31 := diff(Kxt, t\$2); k32 := diff(Kxt, x\$1, t\$2); k33 := diff(Kxt, x\$2, t\$2);$
$DK2 := Matrix(2, 2, [k11, k12, k21, k22]); zDK2 := Determinant(DK2);$
$DK3 := Matrix(3, 3, [k11, k12, k13, k21, k22, k23, k31, k32, k33]); zDK3$
$:= Determinant(DK3);$

$$DK2 := \begin{bmatrix} 3x+2t & 3 \\ 2 & 0 \end{bmatrix}$$

$$zDK2 := -6$$

$$DK3 := \begin{bmatrix} 3x+2t & 3 & 0 \\ 2 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$zDK3 := 0$$

As we see, the value of the determinant $A_2[K](x,t)$is different from zero: $zDK2=-6$, the value of the determinant $A_3[K](x,t)$is zero $zDK3=0$.

Let's compose a conditional ***if*** statement:

if $zDK2 \neq 0$ **and** $zDK3 = 0$ **then** *print* ('Yadro_uravneniya_virogdenno_');
else *print* ('*Yadro_uravneniya_NE_virogdenno*');
fi;

*print Yadro_uravneniya_virogdenno_*

Knowing that the kernel of the equation is degenerate, we find the solution of the integral equation[8]-[9] in the loop:

```
if zDK2 ≠ 0 and zDK3 = 0 then
 p1x := x; q1t := 3; p2x := 2; q2t := t ; fx := 8·x^2 − 5·x;
fr := fx + lambda·(C1·(p1x) + C2·(p2x));
a11 := int((subs(x = t, p1x))·q1t, t = 0 ..1);
a12 := int((subs(x = t, p2x))·q1t, t = 0 ..1);
a21 := int((subs(x = t, p1x))·q2t, t = 0 ..1);
a22 := int((subs(x = t, p2x))·q2t, t = 0 ..1);
f1 := int((subs(x = t, fx))·q1t, t = 0 ..1);
f2 := int((subs(x = t, fx))·q2t, t = 0 ..1);
s := ({C11 − (a11·C11 + a12·C22) = f1, C22 − (a21·C11 + a22·C22) = f2});
 rs := solve(s, {C11, C22}); assign(rs);
req := subs(C1 = C11 , C2 = C22, fr);
 fi;
```

The code of the solution of the integral equation (3) is:

```
restart; with(LinearAlgebra) :
fx := 8·x^2 − 5·x; Kxt := 3·x + 2·t; lambda := 1;
eq := phi(x) = fx + lambda·int(Kxt·phi(t), t = 0 ..1);
k11 := Kxt; k12 := diff(Kxt, x$1); k13 := diff(Kxt, x$2);
k21 := diff(Kxt, t$1); k22 := diff(Kxt, x$1, t$1); k23 := diff(Kxt, x$2, t$1);
k31 := diff(Kxt, t$2); k32 := diff(Kxt, x$1, t$2); k33 := diff(Kxt, x$2, t$2);
DK2 := Matrix(2, 2, [k11, k12, k21, k22]); zDK2 := Determinant(DK2);
DK3 := Matrix(3, 3, [k11, k12, k13, k21, k22, k23, k31, k32, k33]); zDK3
     := Determinant(DK3);
if zDK2 ≠ 0 and zDK3 = 0 then print ('Yadro_uravneniya_virogdenno_');
else print ('Yadro_uravneniya_NE_virogdenno');
fi;
if zDK2 ≠ 0 and zDK3 = 0 then
 p1x := x; q1t := 3; p2x := 2; q2t := t ; fx := 8·x^2 − 5·x;
fr := fx + lambda·(C1·(p1x) + C2·(p2x));
a11 := int((subs(x = t, p1x))·q1t, t = 0 ..1);
a12 := int((subs(x = t, p2x))·q1t, t = 0 ..1);
a21 := int((subs(x = t, p1x))·q2t, t = 0 ..1);
a22 := int((subs(x = t, p2x))·q2t, t = 0 ..1);
f1 := int((subs(x = t, fx))·q1t, t = 0 ..1);
f2 := int((subs(x = t, fx))·q2t, t = 0 ..1);
s := ({C11 − (a11·C11 + a12·C22) = f1, C22 − (a21·C11 + a22·C22) = f2});
 rs := solve(s, {C11, C22}); assign(rs);
req := subs(C1 = C11 , C2 = C22, fr);
 fi;
```

As can be seen, the function $f(x)$, the kernel $K(x,t)$, λ are inserted at the initial stage. Then the integral equation (3) is written down. In the second cycle we insert $p_1(x)=x$, $q_1(t)=3$, $p_2(x)=2$, $q_2(t)=t$, according to the representation $K(x,t)$ in the form (13). The solution of the integral equation is performed in the *LinearAlgebra* package. Approbation of the code on numerous examples of the form (3) allowed us to automate the solution of the Fredholm integral equation with a degenerate kernel[11].

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Issue Article

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NUMERICAL INFORMATION SUPPORTING THE EXTRACTED KNOWLEDGE ABOUT HIDDEN TRACES OF ACCIDENTAL DISASTER, ACCIDENT, EARTHQUAKE, LARGE FLOOD

Abstract*: A cognitive model has been developed for a system of 5 semantic equations with 10=5+5 semantic variables: meaning(y_1),...,meaning(y_5), meaning(z_1),...,meaning(z_5), multiplied by parameter values equal to the components 5 pseudo-eigenvectors satisfying the matrix semantic equality of the form meaning(Z_{m5})=meaning($Y_{m5}C^T_{55}$), where meaning(Z_{m5})=meaning(z_1)⊕...⊕meaning(z_5), meaning($Y_{m5}C^T_{55}$)=meaning($Y_{m5}\mathbf{c}^T_1$)⊕meaning($Y_{m5}\mathbf{c}^T_2$)⊕meaning ($Y_{m5}\mathbf{c}^T_3$)⊕meaning($Y_{m5}\mathbf{c}^T_4$)⊕meaning($Y_{m5}\mathbf{c}^T_5$). The problem without restrictions was solved: (I_{55},I_{55})=>(Λ_{55},C_{55}) and its solution was obtained: Λ_{55}=diag(1.0594, 1.0560, 0.9933, 1.0198, 0.8714), matrix C_{55} (Table 1). A new meaning has been found, based on numerical information, extracted hidden knowledge about the hidden traces of an accidental catastrophe, accident, earthquake, large floods. The meaning phrase is constructed by solving a semantic equation with the semantic unknown variable meaning(y_5). Type of equation: meaning(y_5)=meaning(z_3)*0.1191⊕meaning(z_4)*0.3556⊕meaning(z_5)*0.9116. The understanding of the right side of the equation is formulated in the form of the phrase: “weak (with a force c^2_{15}=$(0.0001)^2$) temperature fluctuations occur (meaning (y_1)), but without fluctuations (with a force c^2_{25} = $(0.0048)^2$) precipitation level (meaning(z_2))". This phrase reasonably alludes to the constant high temperature from a strong fire. At the same time, with the force c^2_{45} = $(0.3556)^2$, the degree of growth in the intensity of strong winds increases (meaning (z_4)) and a strong (with the force c^2_{55} = $(0.9116)^2$) deviation from 0 to the right (increase) of the relative level (a rise in the water level (“sea”) supplied from fire water cannons), formed when extinguishing fires with water. The share of this phenomenon (with the meaning (y_5)=“...") accounts for $\lambda_5/(\lambda_1+...+\lambda_5)$=0.8714/((1.0594+1.0560+ 0.9933+1.0198 +0.8714)=17.43 % of information taken into account by the model. The model cannot use 100% of the information; it takes into account the information that is contained in it plus the information it extracts. Model formulas of correlated z-variables influencing uncorrelated model y-factors y_1,...,y_5 turned out to be effective: the model revealed the presence of the y-variable y_5 (absent in the initial model data) with weak syllables: (y_{i5}*0.1191, y_5*0.1191, y_5*0.1191). in the z-variable z_{i3}, (y_5*0.0048, y_5*0.0048, y_5*0.0048) in the z-variable z_{i2}. The model revealed the absence of the y-variable y_5 (see y_5*0.0001) in the z-variable zi1. But the model also revealed a slightly noticeable presence of the y-variable y_5 (y_5*0.0001) in the z-variables z_{i4},(y_5*0.3556, y_5*0.3556, y_5*0.3556), zi_5 (y_5*0.9116). These little noticeable model values also provide numerical information that substantiates the extracted knowledge about the hidden traces of a random catastrophe, accident, earthquake, or large flood. The model requires: henceforth, strictly consider the sub-factors of meanings meaning (z_4)=“increasing the degree of damage to ecological systems and biological diversity in them (which will entail a reduction in opportunities for services, livelihoods and a reduction in income), meaning (z_5) = “deviation from 0 to the right (increase) of the relative level (sea level rise) caused by the expected increase in temperature".*

Key words*: cognitive model, extracted knowledge about the hidden traces of a random catastrophe, accident, earthquake, large floods.*
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ЧИСЛОВАЯ ИНФОРМАЦИЯ, ОБОСНОВЫВАЮЩАЯ ИЗВЛЕЧЕННОЕ ЗНАНИЕ ОБ СКРЫТЫХ СЛЕДАХ СЛУЧАЙНОЙ КАТАСТРОФЫ, АВАРИИ, ЗЕМЛЯТРЯСЕНИЯ, БОЛЬШИХ ПАВОДКОВ

Аннотация: *Разработана когнитивная модель для системы из 5 смысловых уравнений с 10=5+5 семантическими переменными: смысл(y_1),...,смысл(y_5), смысл(z_1), ...,смысл(z_5), умноженных на значения параметров, равных компонентам 5 псевдособственных векторов, удовлетво ряющих матричному смысловому равенству вида смысл(Z_{m5})=смысл($Y_{m5}C^T{}_{55}$), где смысл(Z_{m5})=смысл(z_1)⊕...⊕смысл(z_5), смысл($Y_{m5}\mathbf{C}^T{}_{55}$)=смысл($Y_{m5}\mathbf{c}^T{}_1$)⊕смысл($Y_{m5}\mathbf{c}^T{}_2$)⊕смысл($Y_{m5}\mathbf{c}^T{}_3$)⊕ смысл($Y_{m5}\mathbf{c}^T{}_4$)⊕смысл($Y_{m5}\mathbf{c}^T{}_5$). Решена задача, лишенная ограничений: (I_{55},I_{55})=>(Λ_{55},C_{55}) и получено ее решение: Λ_{55}=diag(1.0594, 1.0560, 0.9933, 1,0198, 0.8714), матрицу C_{55} (Таблица 1). Найден новый смысл, обоснованный числовой информацией, извлеченным скрытым знанием об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков. Фраза смысла конструируется при решении смыслового уравнения с семантической неизвестной переменной смысл(y_5). Вид уравнения: смысл(y_5)=смысл(z_3)*0,1191⊕смысл(z_4)*0,3556⊕смысл(z_5)*0,9116. Осмысление правой части уравнения формулируется в виде фразы: «происходят слабые (с силой $c^2{}_{15}=(0,0001)^2$) колебания температуры (смысл(y_1)), но без колебания (с силой $c^2{}_{25}=(0,0048)^2$) уровня осадков ((смысл(z_2))». Эта фраза обоснованно намекает на постоянно высокую температуру от сильного пожара. В то же время с силой $c^2{}_{45}=(0,3556)^2$ повышается степень роста интенсивности сильных ветров (смысл(z_4)) и наблюдается сильное (с силой $c^2{}_{55}=(0,9116)^2$) отклонение от 0 вправо (увеличение) относительного уровння (подъема уровня воды («моря»), подаваемых из пожарных водометов), образовавшегося при гашении водой огней пожара. На долю этого этого явления (с смыслом(y_5)=«...») приходится $\lambda_5/(\lambda_1+...+\lambda_5)$=0.8714/((1.0594+1.0560+0.9933+1,0198+0.8714)=17,43% информации, учитываемой моделью. Модель не может использовать 100% информации, она учитывает ту информацию, которая в ней заложена плюс извлеченная ею информация. Модельные формулы коррелированных z-переменных, влияющих на не коррелированные модельные y-факторы y_1,...,y_5 оказались эффективными: модель выявила присутствие y-переменной y_5 (отсутствовавшей в исходных данных модели) со слабыми силами: (смотри* $\mathbf{y_{i5}*0.1191^2}$) *- в z-переменной z_{i3}, (смотри* $\mathbf{y_5*0.0048^2}$) *- в z-переменной z_{i2}. Модель выявила отсутствие y-переменной y_5 (с весьма слабой силой* $\mathbf{y_5*0.0001^2}$) *в z-переменной z_{i1}. Модель выявила мало заметное присутствие y-переменной y_5 (с очень малой силой* $\mathbf{y_5*0.0001^2}$) *в z-переменных - z_{i4} (с силой* $\mathbf{y_5*0.3556^2}$), *- z_{i5} (с силой* $\mathbf{y_5*0.9116^2}$). *Эти мало заметные модельные значения также поставляют собой числовую информацию, обосновывающую извлеченные знания об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков. Модель требует: впредь строго рассматривать подфакторы смыслов смысл(z_4)=«увеличение степени ущерба экологическим системам и биологическому разнообразию в них (что повлечет за собой сокращение возможностей отношении обслуживания, обеспечения средств к существованию и сокращение доходов), смысл(z_5)= «отклонение от 0 вправо (увеличение) относительного уровння (подъема уровня моря), вызванным ожидаемым повышением температуры».*

Ключевые слова: *когнитивная модель, извлеченное знание об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков.*

Введение

Система многосмысловых уравнений с семантическими переменными и с параметрами, равными является формульным выражением аддитивного мышления человека. В разговорной речи человек опирается на смыслы, обосновывая суть произносимого логическими, смысловыми, символьными, числовыми доводами с учетом сил проявления силы связи одного независимого y-фактора (количество их может быть равно 1 или другому числу), зависящего от нескольких зависящих друг от друга z–факторов [1-3]. В качестве семантических переменных рассмотрим имена-смыслы, присущие изменениям климата (факторы y_1, y_2,y_3,y_4), изменениям их последствий на деятельность человека (факторы z_1, z_1, z_1, z_2, z_3, z_4, z_5), и прямым изменениям от аварий, катастроф при работе предприятий, работающих для блага человека (y_5). Параметром слагаемого смысла (из суммы смыслов) смысл(z_{ik})*c_{kj} является сила проявления $c^2{}_{kj}$=corr^2(z_{ik},y_j)<1 равная доле вклада смысла k–ой z–переменной в смысл j–ой y–переменной: смысл(y_{ij})=...⊕смысл(z_{ik})*c_{kj}⊕... Здесь «вес» c_{kj} является выделенным компонентом псевдособственного вектора с номером j. Системе смысловых уравнений соответствует система алгебраических уравнений, содержащих выделенные компоненты псевдособственных векторов. Когнитивная модель изменчивостей показателей климата и негативных показателей деятельности человека в статье описана.

Здесь приведем, в исходных данных которой приведены только 9=4+5 семантическими переменными: смысл(y_1),..., смысл(y_4), смысл(z_1),...,смысл(z_5), умноженных на значения параметров, равных компонентам 4-х псевдособственных векторов. Без учета смысла (y_5) 5-ой переменной, отражающей случайное прямое изменение климата от аварий, катастроф при работе предприятий, работающиж для блага человека. Ниже показано: с учетом долей вкладов смысла(z_3), смысла(z_4), смысла(z_5), новый_смысл (y_5) имеет другую фразу, обоснованную конкретными данными – смысловыми, числовыми. Применим описанную систему в когнитивной модели, количественно и по сути обоснованно извлекающую знания об однаруженных следах случайной катастрофы, аварии, или экологических загрязнений при добыче, переработке нефти, газа.

Изменение климата – один из вопросов развития. Ввиду не отвратимого воздействия этого явления на многие аспекты жизни человека, сегодня, вероятно, оно представляет собой один из наиважнейших факторов климата. Чернобыльская авария, авария на АЭС Фукусима, другие катастрофы требуют ввода в модель смысла фактора: смысл(y_5). С целью: сможет ли модель в фразе, словесно передающей смысл(y_5) «намекнуть или обоснованно выделить знание об смысле(y_5), приведенном в исходных данных к модели». При наличии такого намека можно модели присвоить не только познающую способность, но и способность однаруживать следы неизвестного. Намек должен быть компетентно перепроверен соответствующими специалистами, располагающими совсем другими данными. Негативное воздействие деятельности человека на климат скрывается за высокими заборами промышленных и сырьевых предприятий, а редкие катастрофы, инциденты (вброс в море нефти из буровых платформ, из тонущих танкеров, отравление фауны, флоры океана неустановленными лицами, или при ошибках во время учений, запусков летающих объектов) быстро ликвидируются, но остаются последствия, портящие климат. Заметим: знания и опыт в определённой сфере не стоит путать с умением ими пользоваться. Например, если в компании открыта вакансия юриста, то занять её сможет только человек с высшим юридическим образованием и с другими компетенциями. Но наличие диплома не гарантирует компетентности соискателей. Негативное воздействие деятельности человека на климат является важнейшей проблемой, эту проблему должны решать люди с другими статусами.

Мы будем исследовать систему «изменение климата - природные и хозяйственные воздействия», система обладает асимметрией информации и неполными данными. Но основные смыслы изменчивостей существуют, требуется их обоснованные описания. Актуальными являются системные формализованные междисциплинарные теории воздействия деятельности человека на климат и влияния изменений климата на деятельность человека. Пока ограничимся моделированием в системе «изменение климата - природные и хозяйственные последствия», поиском проявлений немыслимых ситуаций, официально не отражаемых в деловых сказках проектов компаний, задача которых – попасть в список исполнителей проекта, своеобразно регламентирующих его результаты.

Наше исследование отличается от разнообразных исследований, посвященных разным аспектам изменения климата Земли, проведенных в рамках разных отраслей знаний. Имеются краткие сжатые в словесные фразы результаты. Среди них выберем результаты, приведенные в материалах Всемирного банка (заказ ООН). «Богатые страны, которые давно входят в число промышленно развитых, несут основную ответственность за возникновение проблемы изменения климата, в то время как беднейшие общины и страны больше всего страдают от последствий, поскольку, как правило, именно они принимают на себя главный удар сильных наводнений, засух, бурь и других предсказуемых явлений, средств на эффективную борьбу с которыми у них не хватает». По сути, из-за изменения климата, оставляющего людей в нищете, можно потерять то, чего удалось добиться в сфере мирового развития» [1].

Деятельность человека является причиной негативных изменений климата. Измерения показателей изменений климата более доступны (их можно считать полными), чем измерения показателей негативной деятельности одних людей, приведшей к изменению климата. Мы рассматриваем другую группу людей, чья деятельность ухудшилась из-за изменений климата.Мы ниже формализуем сложную систему климат- человек.

Введем показатели деятельности человека и негативных изменений климата, введем параметры, переменные, изменчивости переменных, математические функции, уравнения, системы уравнений, системы многомерных когнитивных уравнений для смыслов изменчивостей переменных, критерии, функции ограничений, целевую функцию.

Исходные данные

Исходными словесными данными [4-6] являются имена-смыслы факторов, а не числовые значения проявлений нормальных или аномальных климатических явлений и показателей негативных проявлений деятельности дюдей. Эти сведения имеются в материалах Всемирного банка[1] и анализируются обычными методами, недостатком которых является добыча поверхностных знаний. Исключение составляют химические методы обработки вновь образовавшихся веществ, иных материалов от разрушений среды. Словесные данные могут выражать даже научно необъясненные, непонятные факторы климатических явлений. Главные негативные показатели (валидные переменные модели) деятельности человека, последствия которых ведут в результате к изменению климата Земли. Их перечень (один из известных) состоит из 4-х показателей. Смыслы этих показателей взяты из материалов Всемирного банка (смотрите в статье [1]). Назначим исходные смыслы-имена y–переменных:

1) Колебания температуры (смысл(y_1)).
2) Колебания уровня осадков ((смысл(y_1))y_2).
3) Годовой уровень осадков, происходящих с большими интервалами, в виде гораздо более сильных и кратковременных ливней, вызывающих усиление засух и наводнений ((смысл(y_1))y_3).
4) Степень роста интенсивности сильных штормов и ураганов (смысл(y_4)).

Исходными именам-смыслам 5 z-изменчивостей (5 z-переменных) назначим:

смысл(z_1) – увеличение степень негативного воздействия на сельское хозяйство в тропиках и субтропиках (угроза продовольственной безопасности);
смысл(z_2) - дальнейшее уменьшение количества воды и ухудшение ее качества в регионах, где бедные общины зависят от дождевой воды, используемой для полива зерновых и для питья;
смысл(z_3) - увеличение степени распространения малярии, лихорадки денге и других болезней в тропических и субтропических регионах (там, где здравоохранение и без того плохо развито, произойдет повышение уровня смертности);
смысл(z_4) - увеличение степени ущерба экологическим системам и биологическому разнообразию в них (что повлечет за собой сокращение возможностей обслуживания, обеспечения средств к существованию и сокращение доходов).
смысл(z_5) - увеличение относительного уровня (подъема уровня моря), вызванным ожидаемым повышением температуры.

Количество z-переменных равно 5, количество y -переменных равно 4. Назначим до момента обнаружения (не вводя в модель) смысл для 5-ой y-переменной: смысл(y_5)=«годовой уровень неизбежных загрязнений при добыче, переработке нефти, газа, землятресении, при больших паводков». Фраза этого смысла отсутствует в текстах используемых нами материалов Всемирного банка. Фразу «…» из смысла(y_5) можем использовать только тогда, когда появится заметный «вес» c_{k5} $k\in\{1,2,3,4,5\}$, в смысловом уравнении смысл(y_{i5})=смысл(z_{i1})*c_{15}⊕смысл(z_{i2})*c_{25}⊕смысл(z_{i3})*c_{35}⊕смысл(z_{i4})*c_{45}⊕смысл(z_{i5})*c_{55}. Если этот критерий не будет выполняться, то семантическая переменная смысл(y_5)=«…» не фигурирует в когнитивной модели: климатические явления и деятельность людей проходит при нулевой степени «загрязнений при добыче, переработке нефти, газа, без землятресений, больших паводков». Такой сценарий заложен в бизнес-плане компании, иначе бы недропользователь не дал бы ей лицензию. Исходными числовыми данными являются 1 значение «веса»: c_{44}=0.86. Этим мы избегаем присутствия данных, которые могут подсказать программе GRD2 о существовании заметной величины компоненты в собственном векторе №5, и тогда появится заметный «вес» c_{k5} $k\in\{1,2,3,4,5\}$, в смысловом уравнении смысл(y_{i5})=смысл(z_{i1})*c_{15}⊕смысл(z_{i2})*c_{25}⊕смысл(z_{i3})*c_{35}⊕смысл(z_{i4})*c_{45}⊕смысл(z_{i5})*c_{55}. Словесно отметим, не вводя в модель не предусмотренных бюджетом проявления катастроф, землятресений, больших паводков. Если модель случайно смоделирует хотя бы одну заметную величину компоненты в собственном векторе №5, то она познает случайное проявление хотя бы одного из бед: катастрофы, землятресения, больших паводков. Если в смоделированной матрице C_{55} отсутствуют указанные индикаторы, то модель исключает случайное проявление катастрофы, землятресения, больших паводков. Тут нет мониторинга текущих факторов. Есть познание системы «изменение климата - природные и хозяйственные последствия».

Словесные описания коррелированных z-изменчивостей климата и z-изменчивостей их последствий от деятельности человека

Словесные описания [4] связанных попарно друг с другом изменений климата и негативных последствий от хозяйственной деятельности человека (способствующих изменениям климата) нужны для формулирования кратких фраз, передающих смыслы вводимых (для когнитивной модели) z-переменных, валидных (вычисляемых) неизмеряемых (но моделируемых) y-переменных (зависящих от некоторых вычисленных z-переменных) математической модели, поставляюшей числовую информацию, обосновывающую извлеченные знания об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков.

Словесные описания изменяющихся числовых показателей следующие: колебания температуры (z_1), колебания уровня осадков (z_2), годовой уровень осадков, происходящих с большими интервалами, в виде гораздо более сильных и кратковременных ливней (z_3), вызывающих усиление засух и наводнений (z_4), рост интенсивности сильных штормов и ураганов (z_5). Краткие фразы смыслов 5 измеряемых (структурами государственных экологических служб) z-переменных модели должны соответствовать приведенным выше типам изменения климата. Краткие фразы смыслов имен-смыслов 5 z-изменчивостей (значений 5 z-переменных) идентичны вышеприведенным смыслам [1]:

z_1 – отклонение от 0 (увеличение/уменьшение) степени негативного воздействия на сельское хозяйство в тропиках и субтропиках (угроза продовольственной безопасности);

z_2 - дальнейшее уменьшение количества воды и ухудшение ее качества в регионах, где бедные общины зависят от дождевой воды, используемой для полива зерновых и для питья;

z_3 -увеличение степени распространения малярии, лихорадки денге и других болезней в тропических и субтропических регионах (там, где здравоохранение и без того плохо развито, произойдет повышение уровня смертности);

z_4 -увеличение степени ущерба экологическим системам и биологическому разнообразию в них (что повлечет за собой сокращение возможностей отношении обслуживания, обеспечения средств к существованию и сокращение доходов).

z_5 – отклонение от 0 вправо (увеличение) относительного уровння (подъема уровня моря), вызванным ожидаемым повышением температуры.

Теперь формально переформулируем смыслы 4-х y–переменных для когнитивного (дополнительно познания) их соответствия вышеприведенным смыслам 5 z-переменных, входящих в каждый из смыслов 4-х y–переменных. исходные смыслы-имена y–переменных:

1) Колебания температуры (y_1). По смыслу y_1 оказывает заметное влияние на показатель «степень ущерба экологическим системам и биологическому разнообразию в них» (z_4).

2) Колебания уровня осадков (y_2). По смыслу y_2 оказывает заметное влияние на показатель «степень негативного воздействия на сельское хозяйство» (z_1), уменьшение количества воды и ухудшение ее качества в регионах (z_2), относительный уровень подъема уровня моря (z_5).

3) Годовой уровень осадков, происходящих с большими интервалами, в виде гораздо более сильных и кратковременных ливней, вызывающих усиление засух и наводнений (y_3). Формула изменчивости y–переменной №3 имеет вид $y_{i3}=z_{i1}*c_{13}+z_{i2}*c_{23}+\ldots+z_{i5}*c_{53}$. По смыслу этот валидный показатель заметно влияет на изменчивость z_{i1} «степени негативного воздействия на сельское хозяйство» (с «весом» c_{13}). Номеру 3 y-переменной в матричной математической модели $Y_{m5}=Z_{m5}C_{55}$ соответствует равенство $y_{i3}=z_{i1}*c_{13}+z_{i2}*c_{23}+\ldots+z_{i5}*c_{53}$, с коэффициентами, равными компонентам $c_{13},c_{23},\ldots,c_{53}$ 3-го собственного вектора $(c_{13},c_{23},\ldots,c_{53})^T$.

4) Степень роста интенсивности сильных штормов и ураганов (смысл(y_4)). Этот валидный показатель заметно влияет на показатель «степень негативного воздействия на сельское хозяйство» (z_1), «степень ущерба экологическим системам и биологическому разнообразию в них» (z_4), на показатель «относительный уровень подъема уровня моря» (z_5). Показатель y_4 имеет более привычный смысл скорости ветра (изменчивость расстояний за единицу времени ds/dt). Интенсивности сильных штормов с меняющимися скоростями создают разные ускорения скоростей ветра и ураганов (dv/dt-объем воды за единицу времени). Этот валидный показатель заметно влияет на показатель «степень негативного воздействия на сельское хозяйство» (z_1), на показатель «относительный уровень подъема уровня моря» (z_5).

Добавим условную семантическую переменную смсл(y_5)=«годовой уровень при добыче, переработке нефти, газа, катастроф, случайного землятрясения, больших паводков» (с фразой ее смысла, которая обосновывается числовой информацией и формирует скрывавшееся, но извлеченное знание об случайной катастрофы, аварии, загрязнений, больших паводков). При этом индикатор присутствия знания не фигурирует в когнитивной модели. Но если он появится, т.е. хотя бы одна из величин c_{k5}=corr(z_k,y_5), k=1,…,5, будет иметь заметное значение, то модель покажет случайное проявление смысла(y_5) в модели. Ее сила проявления c^2_{k5} и ее изменчивость не известны, но будут смоделированы. Они будут получены ниже в 2-х независимых модельных вычислениях (смотрите ниже). Числовой y-фактор y_5 будет некоррелированным с другими y-факторами, ибо соответствует независимому смыслу(y_5). Имя-смысл y-фактора y_5 сформулируем так, как показано ниже. Возможны другие фразы, по смыслу намекающие на суть смысла(y_5).

5) Годовой уровень неизбежных загрязнений при добыче, переработке нефти, газа, при землятрясении, больших паводках. Данный показатель введен в дополнение к типичным 4 факторам. Обычно этот объем издержек не планируется, скрытно обещают не допускать вредных выбросов в атмосферу, в почву, в водоемы. Если в результате ЧП происходит загрязнение окружающей среды, то ведомство по охране экологии точно установит суммы ущеба, штрафов. Поэтому мы не можем в исходных данных назначить планируемое значение

индикатора c_{k5}=cjrr(zk,y_5). Но практика показала, что аварии на буровых установках, на участках цикла переработки нефти, газа, стихийные бедствия происходят и ликвидируются, нейтрализируются. Суммы штрафов, выплачиваемых компаниями, могут быть заложены в бизнес-планы проектов компаний, не зависят от других y–факторов. Нам интересен ответ на вопрос: сможет ли наша когнитивная модель смоделировать сама какое-то значение индикатора c_{k5}=cjrr(z_k,y_5) случайно возможного загрязнения? Использование нами датчика случайных чисел не исключает этого (как убедимся ниже). Мы не вводим ни одного индикатора. Пяти показателям z-изменений климата мы в модели поставили в соответствие 5 y–переменные.

Задача: разработать систему из 5 смысловых уравнений с 10=5+5 семантическими переменными: смысл(y_1),…, смысл(y_5), смысл(z_1),…,смысл(z_5), умноженных на значения параметров, равных компонентам 5 псевдособственных векторов, удовлетворяющих матричному смысловому равенству вида смысл(Z_{m5})=смысл($Y_{m5}C^T_{55}$), где смысл(Z_{m5})=смысл(z_1)⊕…⊕смысл(z_5), смысл($Y_{m5}C^T_{55}$)=смысл($Y_{m5}c^T_1$)⊕смысл($Y_{m5}c^T_2$)⊕смысл($Y_{m5}c^T_3$)⊕смысл($Y_{m5}c^T_4$)⊕смысл($Y_{m5}c^T_5$). Столбцы матрицы C_{55} являются ортогональны, но не нормированы. Этому матричному смысловому равенству соответствует математическое матричное равенство с числовыми переменными вида: $Z_{m5}=Y_{m5}C^T_{55}$.

Решим задачу: (I_{55},I_{55})=>(Λ_{55},C_{55}) и получим ее решение: $\Lambda_{55}=diag(\lambda_1,\lambda_2,…,\lambda_5)$=diag(1.0594, 1.0560, 0.9933, 1,0198, 0.8714), матрицу C_{55} (Таблица 1).

Матрица C_{55} содержат только 1 индикатор. После решения Задачи Оптимизации мы увидим, например, y–переменной №1 соответствуют 3 индикатора c_{11}=corr(z_1,y_1),c_{21}=corr(z_2,y_1), c_{51}=corr(z_5,y_1), присутствия знаний для некоторых из 5 z-переменных, входящих в каждый из смыслов 5-х y–переменных.

Отличие нашей когнитивной модели от прежней модели состоит в отсутствии мозаики индикаторов [3-6].

Мы вынуждены применять, второе правило, так как наша цель – решить задачу, а не констатировать отсутствие метода решения. Тот, кто хочет решить задачу, а не утверждать об отсутствии точного решения, применяет эмпирические приемы, привносящие погрешности. Нам нужно решить задачу, а не обосновывать отсутствие точного решения. Мы разрабатываем когнитивную познающую многомерную модель, состоящую из системы смысловых уравнений. Система смысловых уравнений формируется из системы математических уравнений вида $Y_{m5}= U_{m5}\Lambda^{1/2}_{55}$, случайная декоррелированная матрица U_{m5} обладает свойством $(1/m)U^T_{m5}U_{m5}=I_{55}$, подходит для моделирования матрицы $Y_{m5}=U_{m5}\Lambda^{1/2}_{55}$ с любым спектром Λ_5. Наш модельный спектр Λ_{55}=diag(1.0594,1.0560,0.9933,1.0198,0.8714) является одним из них. В то же время матрица Y_{m5} удовлетворяет равенству $Y_{m5}=Z_{m5}C_{55}$, которое связывает изменчивости y-переменных Y=ZC, $C_{55}C^T_{55}=I_{55}$. $C_{55}C^T_{55}\neq I_{55}$

$y_{i3}=z_{i1}*c_{13}+z_{i2}*c_{23}+…+z_{i5}*c_{53}$, i=1,…,m, с изменчивостями z-переменных. Эти формулы удобны для получения смысловых уравнений для смысл(y_1), …,смысл(y_5).

Полученные после решения Задачи Оптимизации каждое смысловое уравнение после осмысления с обосновывающими: силами проявлений смыслов, величин отклонений от 0 вправо\влево, дают новые знания, сопряженные с смыслами смысл(y_1),…, смысл(y_5).

из показателей связи y-переменной (изменений климата) равен сумме других показателей (z-переменных) с соответствующими «весами» и изменчивостями «весов». Этим мы выражаем не только смысловую, но и числовую связь между изменениями климата и последствиями изменения климата. Последствия выражены в виде негативных природных, экологических факторов, воздействующих на деятельность людей, объединенных в крупные компании.

Матрица C_{55} связывает 2 матрицы: изменчивости z-переменных (Z_{m5}) и изменчивости y –переменных (Y_{m5}). Последствия (изменчивости z -переменных) проявляются в вышеперечисленных негативных показателей результатов деятельности человека. Изменчивости 5 z -переменных входят в изменчивость соответствующей j-ой валидной y–переменной со своими коэффициентами $c_{1j},c_{2j},…,c_{5j}$: $y_{ij}=z_{i1}*c_{1j}+z_{i2}*c_{2j}+…+z_{i5}*c_{5j}$, j=1,…,4. формуле $y_{ij}=z_{i1}*c_{1j}+z_{i2}*c_{2j}+…+z_{in}*c_{nj}$, присутствует смысловое уравнение. Неизвестная изменчивость y_{i1} (в момент времени i∈{1,2…,m}) переменной y_1 вычисляется при известных смыслах неизвестных значений изменчивости z-переменных z_1,z_2,z_3,z_4,z_5 с известными смыслами смысл(y_{i1})=смысл(z_{i1})*c_{k1}+смысл(z_{i2})*c_{k2}+ смысл(z_{i3})*c_{k3}+смысл(z_{i4})*c_{k2}+смысл(z_{i5})*c_{k3}, k=1,2,3,4.

Смысл y_j равен сумме смыслов z-переменных $z_{i1},z_{i2},…,z_{in}$. Имена-смыслы z-переменных z_1,z_2,z_3,z_4,z_5 приведены выше. Условие вхождения смыслов z-переменных в смысл той или иной y - переменной выполнено.

Псевдособственные векторы симметрической матрицы

Псевдособсвенные векторы неиспользуемой симметрической матрицы $W_{55}=C_{55}\Lambda_{55}C^T_{55}$, моделируются при решении Оптимизационной Задачи, исходя из матрицы собсвенных чисел и матрицы I_{55} собственных векторов. И одного индикатора c_{44}=0.86. Полученная матрица C_{55} псевдособсвенных векторов такая, что: $C_{55}C^T_{55}=I_{55}$, $C^T_{55}C_{55}=\neq I_{55}$, $c_jc^T_j$=(1.00000,1.00000, 1.00000, 1.00000, 1.00000), j=1,…,5.

В описываемой ниже модели псевдособсвенные векторы [7-11] являются предпочтительными. Они могут содержать индикаторы присутствия знаний, значения им моделирует процедура GRD2, которая учитывает ограничения вида $C^T_{55}=I_{55}$, $C^T_{55}C_{55}=\neq I_{55}$, $c_jc^T_j$=(1.00000,1.00000, 1.00000, 1.00000, 1.00000), j=1,…,5. Значения остальных элементов матрицы C_{55} моделируются программой GRD2.

В рассматриваемом ниже примере псевдособсвенные векторы показали свои замечательные свойства. Матрица $Z_{m5}=Y_{m5}C^T_{55}=[z_{i.}]$ содержит в качестве своих элементов значения нестандартизованных z-изменчивостей, Точки $\{z_{i.}\}$,i=1,…,m, вписаны в эллипсоид. Длины полуосей эллипсоида, содержащего точки $(z_{i1},z_{i2},\dots,z_{i5})$,i=1,…,m, равны элементам матрицы Λ_{55}=diag(1.0594,1.0560, 0.9933,1,0198,0.8714). Направляющими векторами полуосей гиперэллипсоида являются 5 взаимно перпендикулярных векторов – собственные векторы с единичными длинами. Координаты в декартовой системе координат являются компонентами 5 собственных векторов, объединенных в матрицу C_{55}. Наша полученная в результате решения Оптимизационной Задачи матрица собственных векторов C_{55} обладает свойством ортогональности, но не свойством ортонормированности: $C_{55}C^T_{55}=I_{55}$, $C^T_{55}C_{55}=I_{55}$. Сумма длин полуосей эллипсоида и сумма длин собственных векторов равны 5: Λ_{55}=diag(1.0594,1.0560, 0.9933, 1,0198, 0.8714). Диагональная матрица Λ_{55}=diag(1.0594, 1.0560, 0.9933, 1,0198, 0.8714) (не [1] Λ_{55}=diag(0.9784, 0.7080,1.3301,1.9602,0.0233), при вводе 7 индикаторов) является спектром неиспользуемой нами симметрической матрицы W_{55}, полученной при решении Оптимизационной Задачи без индикаторов: $(\Lambda_{55}=I_{55},C_{55}=I_{55}) => (\Lambda_{55},C_{55})$.

Наш процесс численного моделирования матрицы C_{55} изобразим так: $(I_{55},I_{55})=>(\Lambda_{55},C_{55})$, где I_{55} начальная матрица собственных векторов, I_{55} –диагональная матрица, применяемая для контроля свойств матрицы C_{55} и матрицы $(\Lambda_{55}=I_{55}, C_{55}=I_{55})=>(\Lambda_{55},C_{55})$, где полученные матрицы таковы, что $C_{55}C^T_{55}=I_{55}$, $C^T_{55}C_{55}\neq I_{55}$. Это - Обратная Спектральная Задача $(I_{55},I_{55})=>(\Lambda_{55},C_{55})$, где $C_{55}C^T_{55}=I_{55}$, $C^T_{55}C_{55}\neq I_{55}$, C_{55} - матрица псевдособсвенных векторов. Числовым матрицам (Λ_{55},C_{55}) соответствует модельная числовая матрица Y_{mn} значений изменчивости некоррелированных y–переменных y_1,y_2,y_3,y_4,y_5 с дисперсиями disp$(y_1)=\lambda_1$, disp$(y_2)=\lambda_2$, disp$(y_3)=\lambda_3$, disp$(y_4)=\lambda_4$,disp$(y_5)=\lambda_5\approx 0$. Матрица $Y_{m5}=U_{m5}\Lambda^{1/2}_{55}$ моделируется (Таблица 3) отдельно, она такова, что $(1/m)Y^T_{mn}Y_{mn}=\Lambda_{55}$,$\lambda_1+\lambda_2+\lambda_5+\lambda_4+\lambda_5=5$, далее матрица Y_{m5} преобразуется с помощью матрицы C^T_{55} собственных векторов в матрицу значений изменчивости коррелированных z–переменных $z_1,z_2,\dots,z_5$ по формуле $Z_{m5}=Y_{m5}C^T_{55}$. Для модельных значений y–переменных y_1,y_2,y_3,y_4,y_5 значения z–переменных $z_1,z_2,\dots,z_5$ вычисляются по формулам:

$z_1=y_1*0.9698+y_2*0.0000+y_3*0.0146+y_4*0.2435+y_5*$ 0.0001;

$z_2=y_1*0.0000+y_2*0.9705+y_3*0.0143+y_4*0.2408+y_5*$ 0.0048;

$z_3=y_1*0.0004+y_2*0.0004+y_3*0.9851+y_4*0.1244y_5*$ 0.1191;

$z_4=y_1*0.2439+y_2*0.2411+y_3*0.1276+y_4*0.8600y_5*$ 0.3556;

$z_5=y_1*0.0003y_2*0.0090+y_3*0.1836+y_4*0.3676+y_5*$ 0.9116.

Эти формулы являются особенностью смыслового равенства вида смысл(Z_{m5})= смысл$(Y_{m5}C^T_{55})$. Взаимные динамики значений z–переменных $z_1,z_2,\dots,z_5$, полученных по формулам и динамики влияющих на них случайных y–переменных изображены на Рисунках 4-13.

Когнитивная модель изменчивостей показателей климата и показателей негативной деятельности человека

Смысловые уравнения при вычисленных (исходя из модельных значений y–переменных) значениях z–переменных имеют вид.

смысл(y_1)=смысл(z_1)*0,9698+смысл(z_2)*0,0000+ смысл(z_3)*0,0004+смысл(z_4)*0,2439+ смысл(z_5)*0,0003;

смысл(y_2)=смысл(z_1)*0,0000+смысл(z_2)*0,9705+ смысл(z_3)*0,0004+смысл(z_4)*0,2411+смысл(z_5)*0, 0090;

смысл(y_3)=смысл(z_1)*0,0146+смысл(z_2)*0,0143+ смысл(z_3)*0,9851+смысл(z_4)*0,1276+смысл(z_5)*0, 1836;

смысл(y_4)=смысл(z_1)*0,2435+смысл(z_2)*0,2408+ смысл(z_3)*0,1244+смысл(z_4)*0,8600+смысл(z_5)*0, 3676;

смысл(y_5)=смысл(z_1)*0,0001+смысл(z_2)*0,0048+ смысл(z_3)*0,1191+смысл(z_4)*0,3556+смысл(z_5)*0, 9116.

Начнем конструирование смыслов y-факторов y_5,y_4, y_3, y_2,y_1. Их новые смыслы должны дополнить исходные смыслы y-факторов $y_1,\dots,y_5$, а модель должна показать свою познающую способность извлекать неизвестные или скрытые знания об неизмеренных свойствах обнаруженных ситуаций, отображаемых на языке введенных в модель коэффициентов парных (z,y)-связей, z-изменчивостей, формул зависимости между введенными переменными. Смысловая формула y-фактора состоит суммы не более 5 слагаемых, каждое из которых равно произведению конкретного значения «веса», умноженного на смысл одной z–переменной.

Найдем новый информационно обоснованный смысл смысл(y_5)=смысл(z_3)*0,1191+смысл(z_4)*0,3556+ смысл(z_5)*0,9116. Осмысление правой части уравнения: происходят слабые (с силой $c^2_{15}=(0,0001)^2$) колебания температуры (смысл(y_1)), но без колебания (с силой $c^2_{25}=(0,0048)^2$) уровня осадков ((смысл(z_2)). Эта фраза обоснованно намекает на постоянно высокую температуру от сильного пожара. В то же время с силой $c^2_{45}=(0,3556)^2$ повышается степень роста интенсивности сильных ветров (смысл(z_4)) и наблюдается сильное (с силой $c^2_{55}=(0,9116)^2$) отклонение от 0 вправо (увеличение) относительного уровня (подъема уровня воды («моря»), подаваемых из пожарных водометов), образовавшегося при гашении водой огней пожара. На долю этого явления (с смыслом(y_5)) приходится $\lambda_5/(\lambda_1+\ldots+\lambda_5)$=0.8714/((1.0594+1.0560+0.9933+ 1,0198+0.8714)=17,43% информации, учитываемой моделью. Ясно, что модель не может использовать 100% информации, она учитывает ту информацию, которая в ней заложена плюс извлеченная ею информация. Остальную информацию надо извлекать из других данных. Модель не может все объяснить, не может показать все возможные симптомы случайно возможной техногенной катастрофы со смыслом равным смыслу(y_5)=«годовой уровень неизбежных загрязнений при добыче, переработке нефти, газа, землятрясения, больших паводков». Вывод; с вероятностью 0.17 (среди 5 y-факторов) возможна катастрофа, у которой z–факторы z_1,z_2,z_3, z_4, z_5 проявятся с силами $0,0001^2$, $0,0048^2$, $0,1191^2$, $0,3556^2$, $0,9116^2$. Сумма сил проявлений равна 100%. Модель количественно точна в рамках ее исходных данных.

Рассмотрим **следующую** y-переменную y_4, найдем новый обоснованный смысл новый_смысл(y_4)= «…». смысл(y_4)=смысл(z_4)*0,8600+смысл(z_5)*0,3676. Новый_смысл(y_4)=«происходит (с силой $c^2_{54}=(0,3676)^2$) увеличение относительного уровня (подъема уровня моря), вызванным ожидаемым повышением температуры (с смыслом(z_5)), происходит увеличение степени ущерба экологическим системам и биологическому разнообразию в них (проявленного фактором с смыслом(z_4))».

Новый обоснованный смысл смысл(y_3)≠ новый_смысл(y_3)=смысл(z_3)*0,9851 передается фразой: новый_смысл(y_3)=«увеличение (с большой силой $c^2_{33}=(0,9851)^2$) степени расспространения малярии, лихорадки денге и других болезней в тропических и субтропических регионах (там, где здравоохранение и без того плохо развито, произойдет повышение уровня смертности)».

Аналогично обосновывается семантическая переменная новый обоснованный смысл новый_смысл(y_2)=смысл(z_2)*0,9705 передается фразой: новый_смысл(y_2)=«дальнейшее уменьшение (с силой $c^2_{22}=(0.9705)^2$) количества воды и ухудшение ее качества в регионах, где бедные общины зависят от дождевой воды, используемой для полива зерновых и для питья».

Обосновывание нового смысла переменной y_1 с наибольшей информативностью λ_1=1.0594 следующее: новый_ смысл(y_1)=смысл(z_1)*0,9698 передается фразой: новый_смысл(y_1)= «увеличение/уменьшение (с очень большой силой $c^2_{11}=(0,9698)^2$) степени негативного воздействия на сельское хозяйство (угроза продовольственной безопасности)».

Моделирование значений изменчивостей показателей климата и изменчивостей показателей негативных видов деятельности человека

Алгоритм вычисления матрицы C_{55}: $(I_{55},I_{55})\Rightarrow(\Lambda_{55},C_{55})$, где $\Lambda_{55}=\mathrm{diag}(\lambda_1,\lambda_2,\ldots,\lambda_5)$=diag(0.9784, 0.7080, 1.3301, 1.9602, 0.0233), значения $\lambda_1, \lambda_2,\ldots,\lambda_5$ равны длинам полуосей гиперэллипсоида. Длины 5 перпендикулярных полуосей, направленных вдоль 5 собственных векторов равны значениям 5 собственных чисел: $\mathbf{c^T{}_1c_1}$=1.0000, λ_1=0.9784, $\mathbf{c^T{}_2c_2}$=1.0000, λ_2=0.7080,$\mathbf{c^T{}_3c_3}$=1.0208, λ_3=1.5501, $\mathbf{c^T{}_4c_4}$=1.0075, λ_4=1.9602, $\mathbf{c^T{}_5c_5}$=0.9718, λ_5=0.0233. Здесь мы видим слабую выраженность псевдособственности векторов.

Полученные в результате решения Оптимизационной Задачи новые длины полуосей в сумме равны 5, что свидетельствует об качественной работе программы GRD2. Гиперэллипсоид с этими модельными длинами полуосей 0.9784, 0.7080,1.3301, 1.9602, 0.0233 отличающимися друг от друга длинами полуосей получен с применением матрицы C_{55} к гипершару с единичными длинами радиуса: (1,1,1,1,1). Для каждой матрицы C_{nn}, n>2, существует свой n–мерный гиперэллипсоид. Значения длин (1,1,1,1,1) начальных векторов мы интерпретировали как нейтральные собственные числа, соответствующие нейтральной системе собственных векторов $I_{55}=C_{55}$. Цель состоит в поиске матрицы C_{55}, при решении

Оптимизационной задачи без наличия индикаторов. И мы ее достигли.

Оптимизационная Задача и новые ограничения

Новые функции ограничений помогут работе программы GRD2 избавиться от лишних ограничений в рамках Оптимизационной задачи. Пусть заданы значение размерности n=5 для пары неизвестных матриц (Λ_{55},C_{55}), для которых заданы начальные значения диагональных элементов матрицы собственных чисел Λ_{55}=diag($\lambda_1,\lambda_2,\ldots,\lambda_5$)= diag(1,1.1,1,1), собственных векторов $C_{55}=I_{55}$. Матрица собственных векторов должна обладать свойством ортонормированности строк и столбцов: diag($C_{55}C^T_{55}$)=diag(1,1.1,1,1), diag($C^T_{55}C_{55}$)=diag(1,1.1,1,1). Здесь заданы 5+4=9 ограничений, а не 25 при ограничении $C_{55}C^T_{55}=I_{55}$, C^T_{55} $C_{55}=I_{55}$. При заданных значениях ее выделенных элементов – индикаторов присутствия скрытых знаний: c_{41}=0.40, c_{12}=0.58, c_{22}=0.56, c_{52}=0.17, c_{15}=0.50,c_{14}=0.25,c_{44}=0.86. Требуется смоделировать пару матриц (Λ_{55},C_{55}): (I_{55},I_{55})=>(Λ_{55},C_{55}).

Напомним, что нам требуется найти матрицу собственных чисел и матрицу псевдособственных векторов, используя процедуру Soler (надстройка Поск решения в ЭТ Эксель), где программа GRD2 итеративно вычисляет методом Ньютона пару матриц (Λ_{55},C_{55}). Никаких дополнительных ограничений, кроме 5+5+5+1 на 25+5=30 элементов матриц, не должно быть в окне ограничений процедуры Soler, кроме вышеперечисленных: n=5, c_{44}=0.86 - с заметно высоким значением.

Прием избегания от двойного и более попадания значения одного элемента из функций ограничений для программы GRD2

В роли изменяемых ячеек процедуры Soler (Рисунок 3) назначим все 25 элементов матрицы собственных векторов C_{55}, этим мы позволяем программе GRD2 изменять все значения, включая заданное одно c_{44}=0.86.

Программа - таблица Оптимизационной Задачи (Рисунок 1): целевая функция имеет $\lambda_1+\lambda_2+\lambda_5+\lambda_4+\lambda_5=5$, функции ограничений задаем не в виде ограничений на все 25 элементов матриц Λ_{55}, C_{55}:$C_{55}C^T_{55}=I_{55}$, $C^T_{55}C_{55}=I_{55}$, а в виде 6 нижеприведенных равенств, где в их формулах присутствуют квадраты значений 7 выделенных компонент 4-х (из 5) собственных векторов. Сами 7 элементов мы не назначаем индикаторами, обнаружить индикаторы должна программа GRD2, в исходных данных к ней нет намека на существование индикаторов-компонент 5-го собственного вектора. При этом длинам 4-х векторов (игнорируя всячески значения компонент 5-го вектора) позволяем быть больше 1, т.е. матрица может быть матрицей псевдособственных векторов: $C_{55}C^T_{55}=I_{55}$, $C_{55}C^T_{55}\neq I_{55}$.

Этот прием, когда избегаем назначать функции ограничений в виде $C_{55}C^T_{55}\neq I_{55}$, назовем «прием избегания от двойного и более попадания значения одного элемента из разных функций ограничений». Компоненты 5-го собственного вектора отсутствуют в формулах ограничений. Этим мы даем свободу программе GRD2 (22 (из 30) элемента связаны ограничениями) в ее итерационной работе по достижению требуемых значений и равенств. Если после решения (Λ_{55},C_{55}): (I_{55},I_{55})=>(Λ_{55},C_{55}) программа GRD2 смоделирует (надеемся мы) хотя бы одно заметное значение c_{k5}, $k\in\{1,2,3,4,5\}$, то слагаемое $z_{ik}*c_{k5}$ в формуле $y_{i5}=z_{i1}*c_{15}+z_{i2}*c_{25}+\ldots+z_{i5}*c_{n55}$, смысл переменной y_5 равен сумме смыслов z-переменных $z_{i1},z_{i2},\ldots,z_{in}$, смысл($y_5$)=«». Этим модель формально обнаружит наличие дополнительного y-фактора с смыслом(y_5)= «». Это будет так, если фраза нового_смысла (y_5) не противоречит фразе смысла(y_5). Иначе возникший когнитивный диссонанс не позволит считать обоснованным смысловое равенство смысл(y_5)=смысл(z_1)*$c_{15}\oplus$смысл(z_2)*$c_{25}\oplus$ смысл(z_3)*$c_{35}\oplus$смысл(z_4)*$c_{45}\oplus$смысл(z_5)*c_{55}.

Назначим для программы GRD2 изменяемые значения: матрица Λ_{55}=diag ($\lambda_1,\lambda_2,\ldots,\lambda_5$). Назначим другие функции ограничений: diag($C_{55}C^T_{55}$)≠diag(1,1.1,1,1), diag($C^T_{55}C_{55}$)=diag(1,1.1,1,1),
$c^2_{11}+c^2_{21}+c^2_{31}+\mathbf{c^2_{41}}+c^2_{51}\geq 1$,
$\mathbf{c^2_{41}}+c^2_{42}+c^2_{43}+\mathbf{c^2_{44}}+c^2_{45}=1$,
$\mathbf{c^2_{12}}+\mathbf{c^2_{22}}+c^2_{32}+c^2_{42}+\mathbf{c^2_{52}}\geq 1$,
$c^2_{51}+\mathbf{c^2_{52}}+c^2_{53}+c^2_{54}+c^2_{55}=1$,
$\mathbf{c^2_{13}}+c^2_{23}+c^2_{33}+\mathbf{c^2_{43}}+c^2_{53}\geq 1$,
$\mathbf{c^2_{14}}+c^2_{24}+c^2_{34}+\mathbf{c^2_{44}}+c^2_{54}\geq 1$, $\lambda_1+\lambda_2+\lambda_5+\lambda_4+\lambda_5=5$.

Почему используем эти 7 равенств (вместо 5+5 ограничений, воздействующих на 5*5=25 элементов, одни элементы из C_{55} подпадают под разные условия, их программа не может учесть и выполнить) в виде функций ограничений? В статье [1] были назначены конкретные значения 7 элементов c_{41}=0.40, c_{12}=0.58, c_{22}=0.56, c_{52}=0.17, c_{13}=0.50, c_{14}=0.25, c_{44}=0.86. Теперь в этой статье не назначаем конкретные значения этим 7 элементам, а задаем 7 функций ограничений, влияющих один раз на один элемент матрицы C_{55} Для пар индексов этих 7 элементов должны выполняться 7*2=14 равенств. Составим таблицу соответствий 7 элементов к виду функций ограничений, удалим повторяющиеся, получим 7 функций ограничений (окрашены в желтый цвет): c_{41}=0.40, i=4, j=1 => $c^2_{11}+c^2_{21}+c^2_{31}+\mathbf{c^2_{41}}+c^2_{51}=1$,

$c^2_{41}+c^2_{42}+c^2_{43}+c^2_{44}+c^2_{45}=1$, $c_{12}=0.58$, i=1, j=2 =>
$c^2_{12}+c^2_{22}+c^2_{32}+c^2_{42}+c^2_{52}=1$,
$c^2_{11}+c^2_{12}+c^2_{13}+c^2_{14}+c^2_{15}=1$,
$c_{22}=0.56$, i=2, j=2 => $c^2_{12}+c^2_{22}+c^2_{32}+ c^2_{42}+c^2_{52}=1$,
$c^2_{11}+c^2_{12}+c^2_{22}+c^2_{32}+c^2_{42}+c^2_{52}=1$,
$c_{52}=0.17$, i=5, j=2 => $c^2_{12}+c^2_{22}+c^2_{32}+ c^2_{42}+c^2_{52}=1$,
$c^2_{51}+c^2_{52}+c^2_{53}+c^2_{54}+c^2_{55}=1$,
$c_{13}=0.30$, i=1, j=3 => $c^2_{13}+c^2_{23}+c^2_{33}+ c^2_{43}+c^2_{53}=1$,
$c^2_{11}+c^2_{12}+c^2_{13}+c^2_{14}+c^2_{15}=1$,
$c_{14}=0.25$, i=1, j=4 => $c^2_{14}+c^2_{24}+c^2_{34}+ c^2_{44}+c^2_{54}=1$,
$c^2_{11}+c^2_{12}+c^2_{13}+c^2_{14}+c^2_{15}=1$,
$c_{44}=0.86$, i=4, j=4 => $c^2_{14}+c^2_{24}+c^2_{34}+ c^2_{44}+c^2_{54}=1$,
$c^2_{41}+c^2_{42}+c^2_{43}+c^2_{44}+c^2_{45}=1$.

Исключив повторные равенства, имеем 7 равенств и неравенств для применения в качестве функций ограничений.

1,0000	1,0000	1,0208	1,0075	0,9718			5,0000			
0,9698	0,0000	0,0146	0,2435	0,0001	1,0000	1,0594				
0,0000	0,9705	0,0143	0,2408	0,0048	1,0000		1,0560			
0,0004	0,0004	0,9851	0,1244	0,1191	1,0000			0,9933		
0,2439	0,2411	0,1276	0,8600	0,3556	1,0000	0,9405			1,0198	
0,0003	0,0090	0,1836	0,3676	0,9116	1,0000	1,8E-07				0,8714
1,0000	0,0036	0,0336	0,2695	0,0187	1,0741	0,9405				
0,0036	1,0000	0,0691	0,3383	0,2031	1,1605					
0,0318	0,0324	1,0000	0,2709	0,2605	1,1433					
0,4946	0,4882	0,2599	1,0000	0,3720	1,6889					
0,0463	0,0635	0,3873	0,5537	1,0000	1,4628					
{c41=0.6, c12=0.6; : c22=0.6, c52=0.6; c13=0.6; c14=0.6, c44=0.6, c54=0.6}									5,0000	
c41	0,40		1,0000	1,0000						
c12	0,29		1,0000				0,0000			
c22	0,45						0,0000			
c52	0,13			1,0000			0,4479			
c13	0,30		1,0208				0,0925			
c14	0,26		1,0075							
c44	0,86									

Рисунок 1. Таблица-программа решения Оптимизационной Задачи

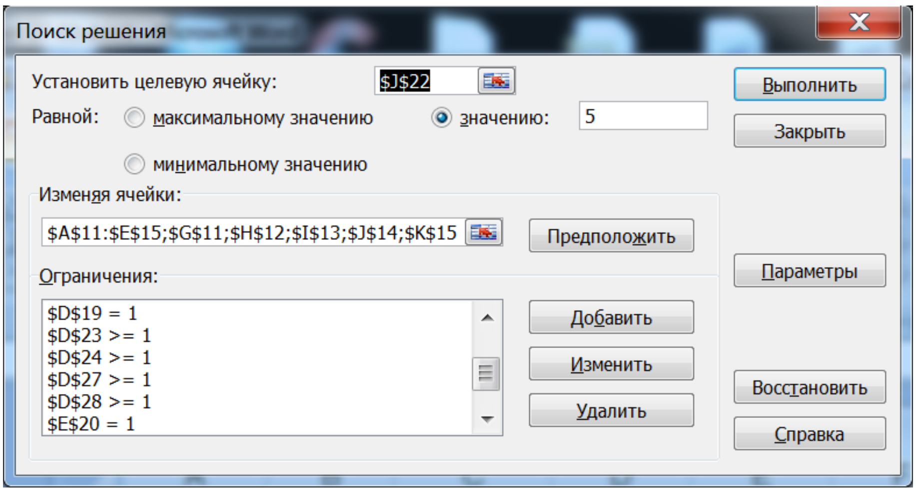

Рисунок 2.Окно надстройки «Поиск решения» решения
Для программы-таблицы Оптимизационной Задачи

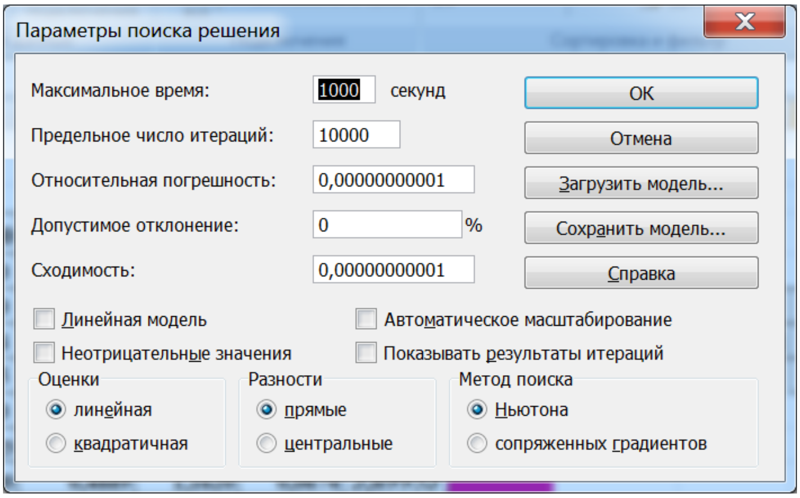

Рисунок 3. Параметры программы – таблицы Оптимизационной Задачи

Таблица 1. Модельные значения «весов» C_{55} климата и негативных показателей деятельности человека (при спектре Λ_{55}=diag(1.0594, 1.0560, 0.9933, 1,0198, 0.8714)

№	c1	c_2	c_3	c_4	c_5	
|c|→	1.0000	1.0000	1.0208	1.0075	**0.9718**	$\|c^T\|$
1	**0.9698**	0.0000	**0.0146**	**0.2435**	0.0001	1.0000
2	0.0000	**0.9705**	**0.0143**	**0.2408**	0.0048	1.0000
3	0.0004	0.0004	**0.9851**	**0.1244**	**0.1191**	1.0000
4	**0.2439**	**0.2411**	**0.1276**	**0.8600**	**0.3556**	1.0000
5	0.0003	0.0090	**0.1836**	**0.3676**	**0.9116**	1.0000

Таблица 2. Матрица Um5 декоррелированных переменных с единичными дисперсиями

1	-0.7016	-0.9343	2.0007	0.4379	-1.3853
2	0.3578	-0.2303	0.6739	-1.6480	-0.1526
3	-0.5641	0.0295	-1.4800	0.0623	1.7922
4	0.4132	0.6219	-1.4043	1.4924	-0.5706
5	2.5272	0.1132	-1.3276	-0.9840	-0.6011
6	-0.0813	0.9842	0.6397	-1.9603	0.6260
7	-0.3182	0.8229	-1.5703	0.7121	0.2875
8	0.2962	0.3621	-0.1774	0.8905	0.6430
9	1.5905	-0.6824	-0.0665	1.7102	0.2861
10	0.6046	0.1983	-0.0153	-0.4762	1.8268
11	-0.4636	-1.2013	-1.5190	-0.8297	-0.2170
12	-0.8385	1.9626	0.2563	-0.4332	-0.3963
13	-1.2432	2.3348	-0.1417	0.1865	-0.7910
14	-0.7099	0.2016	0.7614	1.1353	1.6461
15	-0.6010	-0.6983	1.1184	1.6857	0.4065
16	-0.4747	-1.6261	0.7747	-0.4129	0.7879
17	-1.2833	-1.4178	-0.1666	0.1153	-1.0149

18	-0.5437	1.1126	1.1332	-0.9262	0.0976
19	0.5356	-0.9952	0.0587	-1.0012	1.1755
20	1.5301	0.6093	1.5856	1.0078	0.3098
21	-1.7024	-0.7574	-0.9814	-0.5728	-0.4003
22	-0.4225	-0.5754	-0.8971	0.6461	-1.5257
23	1.1506	0.5651	0.4378	0.0294	-1.9231
24	0.9422	-0.7993	0.3068	-0.8670	-0.9070
	0.0000	0.0000	0.0000	0.0000	0.0000
	1.0000	**1.0000**	**1.0000**	**1.0000**	**1.0000**

Таблица 3. Матрица Y_{m5} y-отклонений

	y 1	y 2	y 3	y 4	y 5
1	-0.7221	-0.9602	1.9940	0.4422	-1.2932
2	0.3683	-0.2367	0.6716	-1.6642	-0.1425
3	-0.5806	0.0303	-1.4751	0.0629	1.6730
4	0.4253	0.6390	-1.3996	1.5071	-0.5327
5	2.6012	0.1163	-1.3232	-0.9937	-0.5612
6	-0.0836	1.0114	0.6375	-1.9796	0.5843
7	-0.3275	0.8457	-1.5651	0.7191	0.2684
8	0.3048	0.3721	-0.1768	0.8992	0.6003
9	1.6370	-0.7013	-0.0662	1.7270	0.2670
10	0.6222	0.2038	-0.0152	-0.4809	1.7053
11	-0.4771	-1.2345	-1.5139	-0.8378	-0.2025
12	-0.8631	2.0168	0.2554	-0.4375	-0.3699
13	-1.2796	2.3993	-0.1412	0.1883	-0.7384
14	-0.7307	0.2071	0.7589	1.1465	1.5366
15	-0.6185	-0.7176	1.1147	1.7023	0.3795
16	-0.4885	-1.6710	0.7721	-0.4169	0.7355
17	-1.3209	-1.4570	-0.1660	0.1164	-0.9474
18	-0.5596	1.1434	1.1294	-0.9353	0.0911
19	0.5512	-1.0227	0.0585	-1.0111	1.0973
20	1.5749	0.6262	1.5803	1.0177	0.2892
21	-1.7522	-0.7784	-0.9781	-0.5784	-0.3737
22	-0.4349	-0.5913	-0.8941	0.6524	-1.4242
23	1.1843	0.5808	0.4364	0.0297	-1.7952
24	0.9697	-0.8214	0.3058	-0.8755	-0.8467
	0.0000	0.0000	0.0000	0.0000	0.0000
	1.0594	1.0560	0.9933	1.0198	0.8714

Таблица 3. Матрица Z_{m5} z-отклонений от 0

	z 1	z 2	z 3	z 4	z 5
1	-0,563577	-0,802928	1,864577	-0,232777	-0,65908
2	-0,038273	-0,621491	0,437648	-1,363426	-0,62032
3	-0,569207	0,0314012	-1,246249	0,326511	1,27757
4	0,758921	0,9604421	-1,254203	1,1858589	-0,18274
5	2,261265	-0,148078	-1,492675	-0,560448	-1,11805
6	-0,553764	0,5167695	0,451698	-1,189847	-0,06878
7	-0,165405	0,9726721	-1,420066	0,6381274	0,22918
8	0,512034	0,577973	0,009495	1,1283371	0,84876
9	2,007169	-0,264366	0,181793	1,8020242	0,86021

10	0,48624	0,0899105	0,128555	0,3918733	1,37707
11	-0,688877	-1,422455	-1,620381	-1,399785	-0,78187
12	-0,939789	1,8538181	0,153605	-0,199443	-0,43314
13	-1,197189	2,3682343	-0,203134	0,1476615	-0,60856
14	-0,418263	0,495333	1,072884	1,5010202	1,9633
15	-0,169041	-0,268709	1,354409	1,4172945	1,1697
16	-0,563969	-1,707473	0,79534	-0,520497	0,64381
17	-1,255102	-1,392845	-0,263018	-0,931482	-0,8649
18	-0,753888	0,901	1,007284	-0,488649	-0,04318
19	0,289326	-1,229884	0,062314	-0,583903	0,63037
20	1,798233	0,8767811	1,718686	1,714903	0,93401
21	-1,854461	-0,910474	-1,081051	-1,370255	-0,74037
22	-0,27607	-0,436354	-0,969621	-0,308179	-1,22821
23	1,161992	0,5683948	0,220549	-0,128332	-1,53998
24	0,731672	-1,007627	0,091536	-0,976542	-1,04473
	0,0000	**0,0000**	**0,0000**	**0,0000**	**0,0000**
	1,0570	**1,0539**	**0,9920**	**1,0051**	**0,8956**

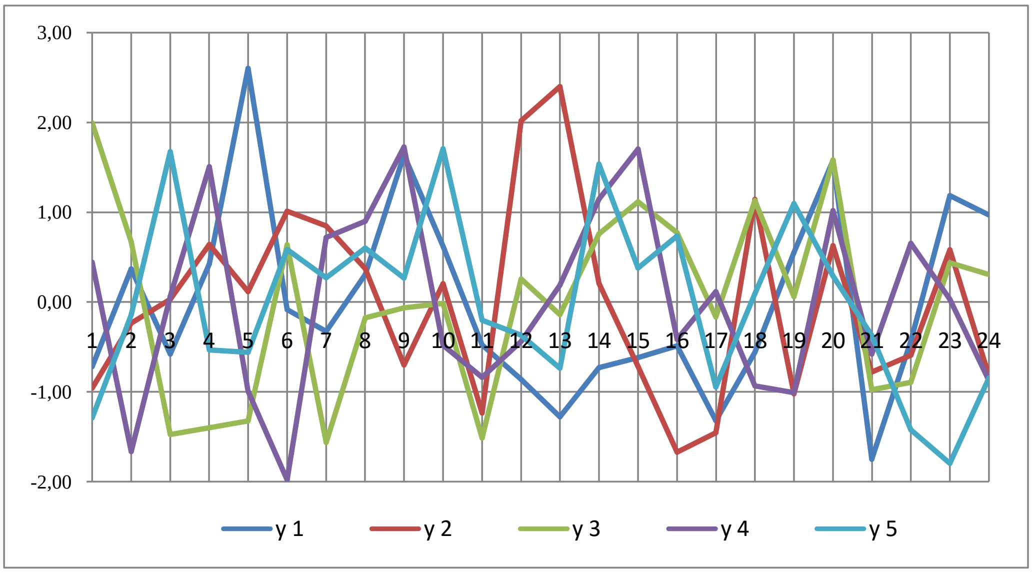

Рисунок 4. Взаимные динамики некоррелированных y-переменных y_1, y_2, y_3, y_4, y_5, $(1/m)Y^T_{m5}Y_{m5}$=diag(0.9784,0.7080,1.3301, 1.9602,0.0233), 0.9784+0.7080+1.3301+1.9602+0.0233=5

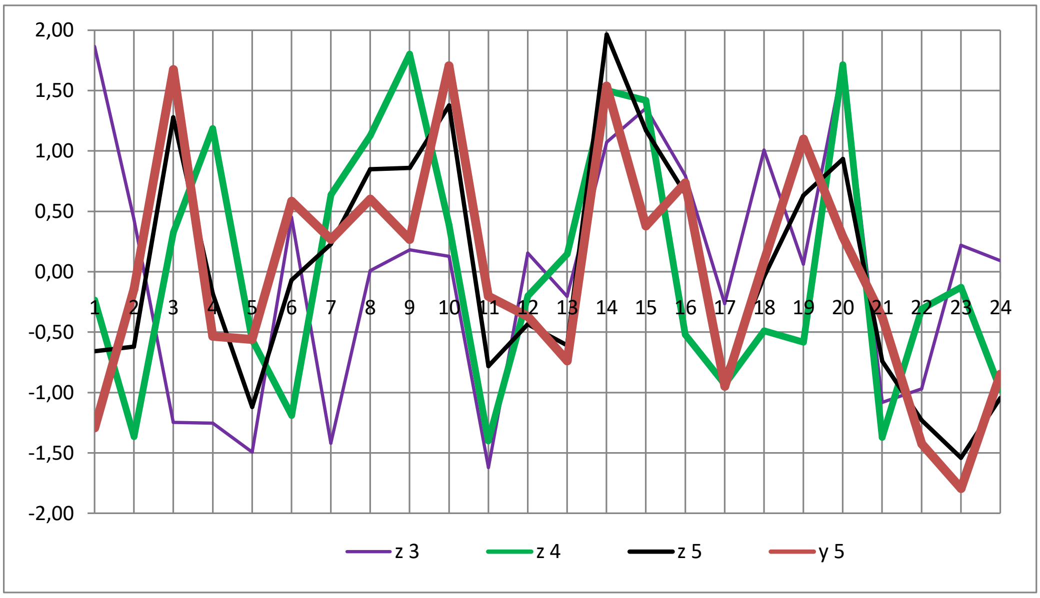

Рисунок 5. Взаимная динамика переменных z_3, z_4, z_5,y_5
$z_{i3} = y_{i1}* 0.0004+ y_{i2}*0.0004+ y_{i3}*0.9851\ y_{i4}*0.1244 +y_{i5}*0.1191$
$z_{i4} = y_{i1}*0.2439+ y_{i2}*0.2411+ y_{i3}*0.1276+ y_{i4}*0.8600+y_{i5}*0.3556$
$z_{i5} = y_i1*0.0003\ y_{i2}*0.0090+ y_{i3}*0.1836+ y_{i4}*0.3676+y_{i5}*0.9116$
y_5, i=1,…,24 (Таблица 3)

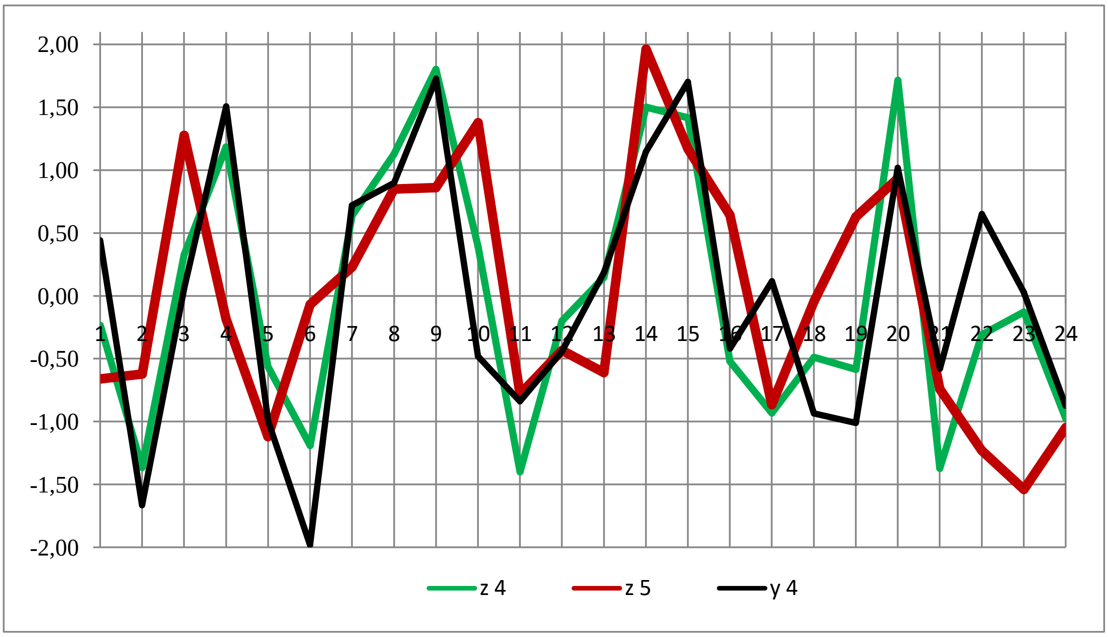

Рисунок 6. Взаимная динамика переменных z_4, z_5,y_4
$z_{i4} = y_{i1}*0.2439+ y_{i2}*0.2411+ y_{i3}*0.1276+ y_{i4}*0.8600\ y_{i5}*0.3556$
$z_{i5} = y_i1*0.0003\ y_{i2}*0.0090+ y_{i3}*0.1836+ y_{i4}*0.3676+y_{i5}*0.9116$
y_4, i=1,…,24 (Таблица 3)

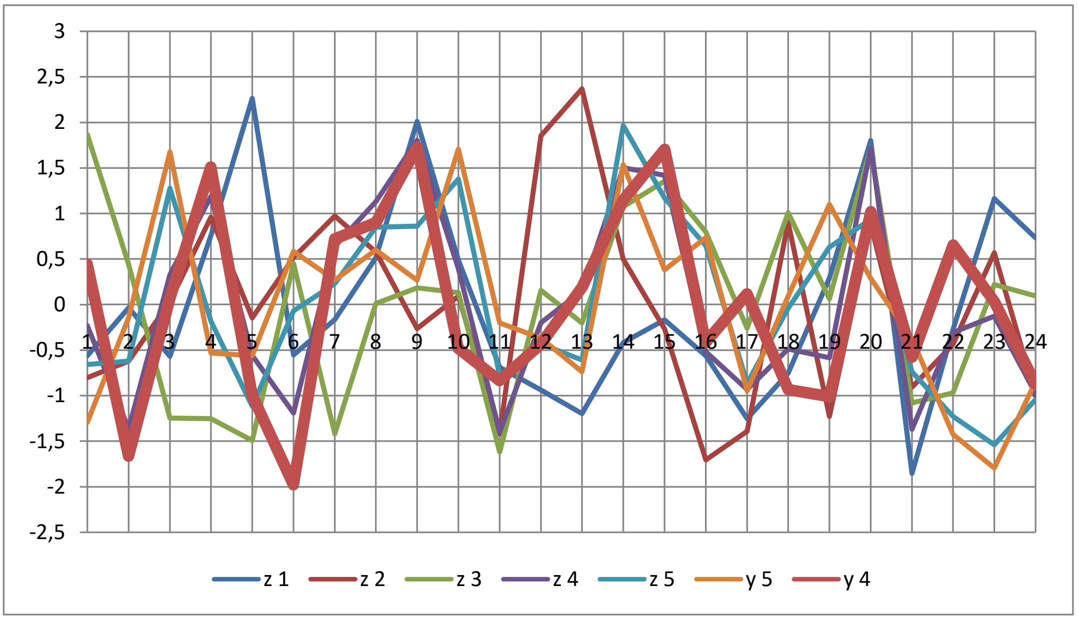

Рисунок 7. Взаимная динамика переменных z_1,z_2, z_3,z_4, z_5,y_4

z_1 = y_1*0.9698+ y_2*0.0000+ y_3*0.0146+ y_4*0.2435+ y_5*0.0001

z_2 = y_1*0.0000+ y_2*0.9705+ y_3*0.0143+ y_4*0.2408+ y_5*0.0048

z_3 = y_1* 0.0004+ y_2*0.0004+ y_3*0.9851 y_4*0.1244+ y_5*0.1191

z_{i4} = y_{i1}*0.2439+ y_{i2}*0.2411+ y_{i3}*0.1276+ y_{i4}*0.8600+ y_{i5}*0.3556

z_{i5} = y_i1*0.0003 y_{i2}*0.0090+ y_{i3}*0.1836+ y_{i4}*0.3676+y_{i5}*0.9116

y_4, i=1,…,24 (Таблица 3)

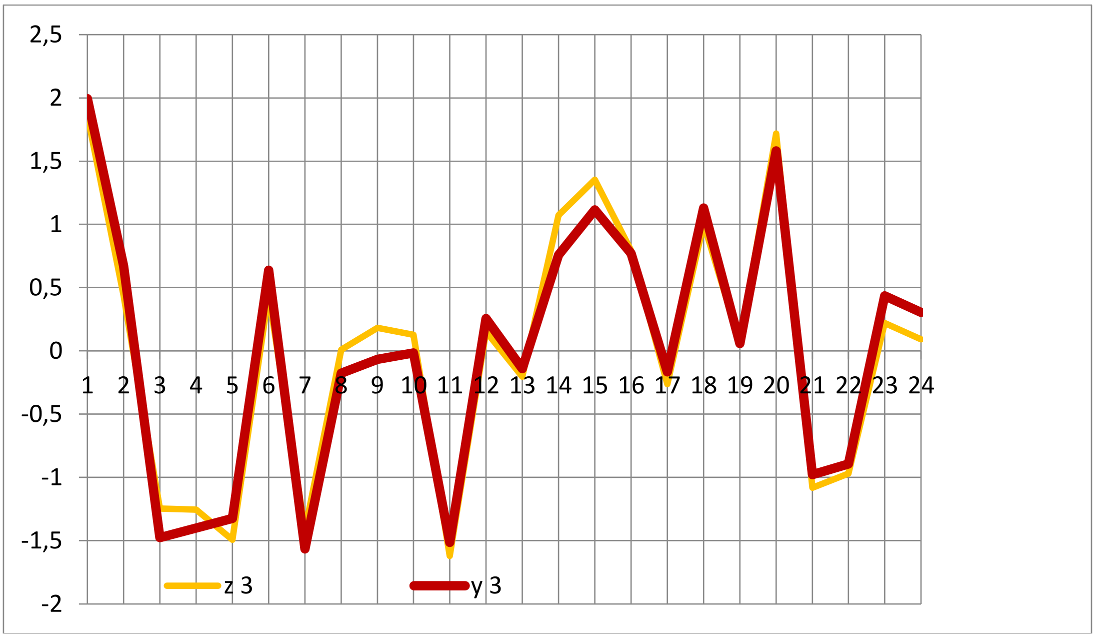

Рисунок 8. Взаимная динамика переменных z_3,y_3

z_{i3} = y_{i1}* 0.0004+ y_{i2}*0.0004+ y_{i3}*0.9851 y_{i4}*0.1244 y_{i5}*0.1191

y_3, i=1,…,24 (Таблица 3)

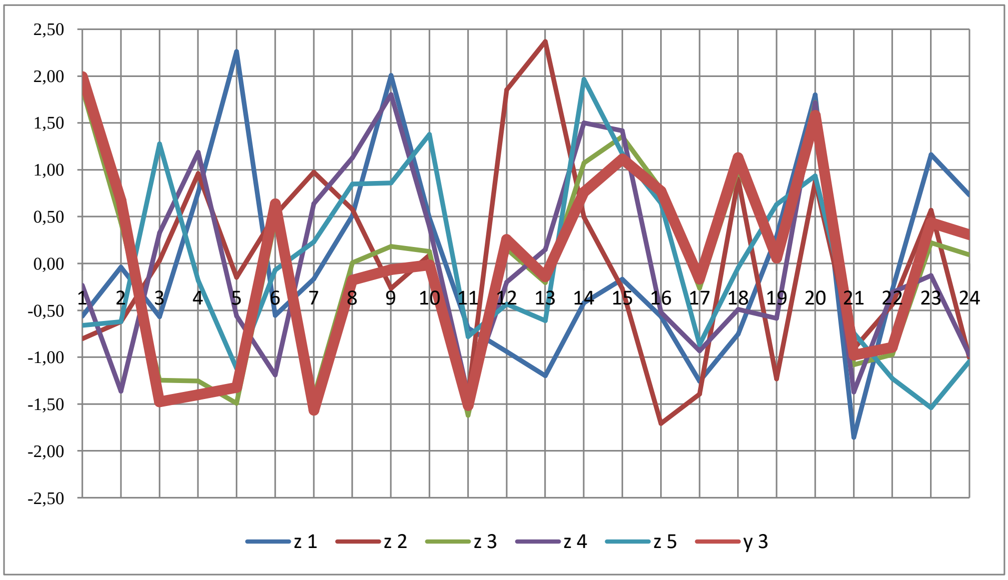

Рисунок 9. Взаимная динамика переменных z_1,z_2, z_3,z_4, z_5,y_3

$z_1 = y_1*0.9698+ y_2*0.0000+ y_3*0.0146+ y_4*0.2435+ y_5*0.0001$

$z_2 = y_1*0.0000+ y_2*0.9705+ y_3*0.0143+ y_4*0.2408+ y_5*0.0048$

$z_3 = y_1* 0.0004+ y_2*0.0004+ y_3*0.9851\ y_4*0.1244+ y_5*0.1191$

$z_4 = y_1*0.2439+ y_2*0.2411+ y_3*0.1276+ y_4*0.8600 +y_5*0.3556$

$z_5 = y1*0.0003\ y_2*0.0090+ y_3*0.1836+ y_4*0.3676+y_5*0.9116$.

y_3, i=1,…,24 (Таблица 3)

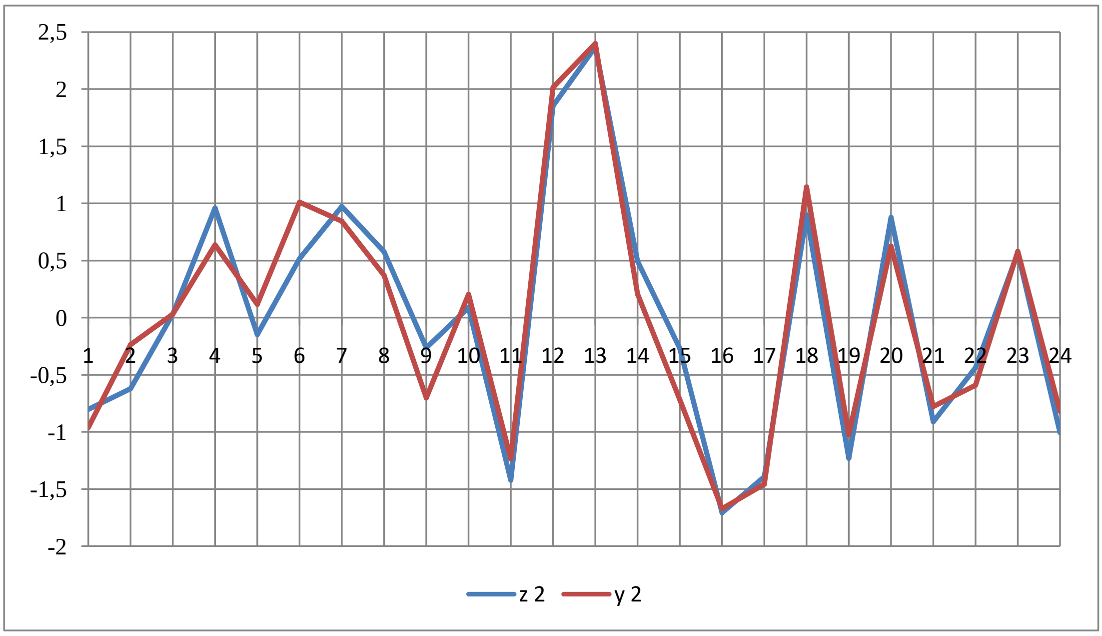

Рисунок 10. Взаимная динамика переменных z_2,y_2

$z_2 = y_1*0.0000+ y_2*0.9705+ y_3*0.0143+ y_4*0.2408+ y_5*0.0048$

y_2, i=1,…,24 (Таблица 3)

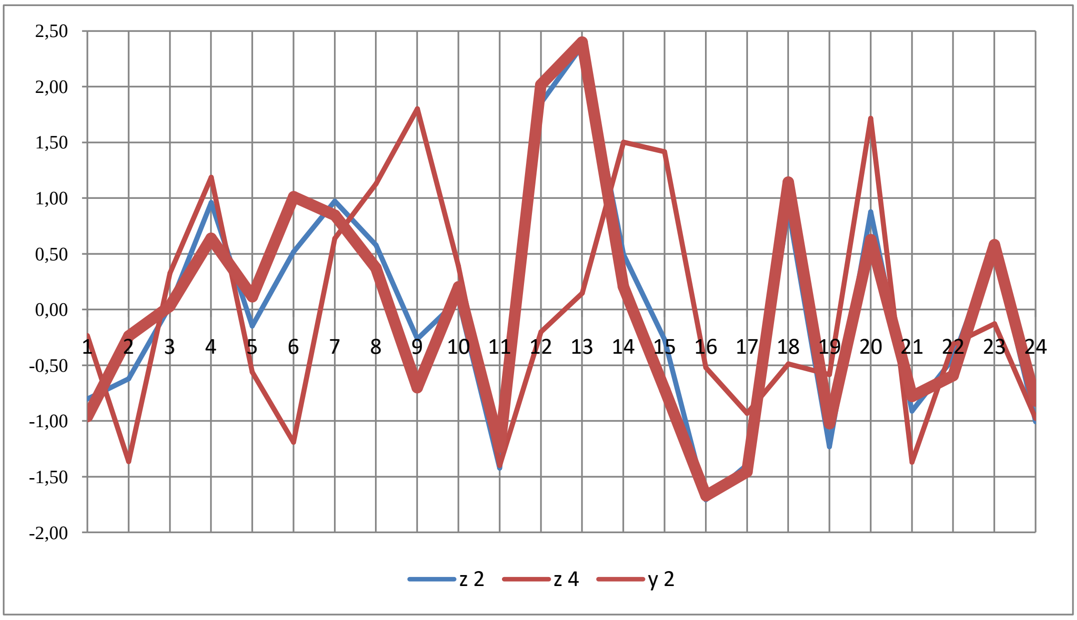

Рисунок 11. Взаимная динамика переменных z_2, z_4, y_2
$z_2 = y_1*0.0000 + y_2*0.9705 + y_3*0.0143 + y_4*0.2408 + y_5*0.0048$
$z_4 = y_1*0.2439 + y_2*0.2411 + y_3*0.1276 + y_4*0.8600 + y_5*0.3556$
y_2, i=1,…,24 (Таблица 3)

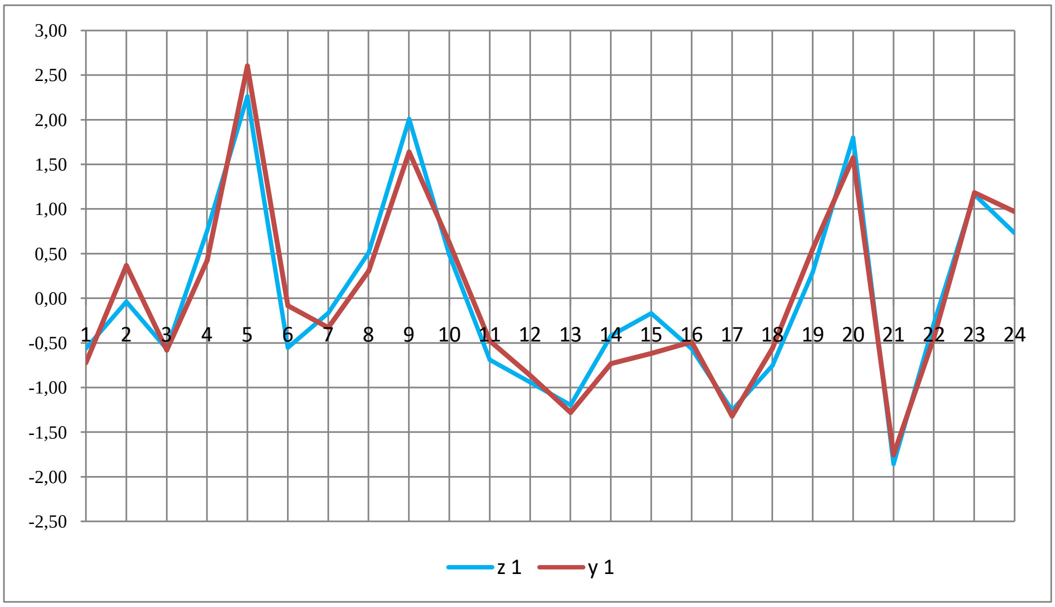

Рисунок 12. Взаимная динамика переменных z_1, y_1
$z_1 = y_1*0.9698 + y_2*0.0000 + y_3*0.0146 + y_4*0.2435 + y_5*0.0001$
y_1, i=1,…,24 (Таблица 3)

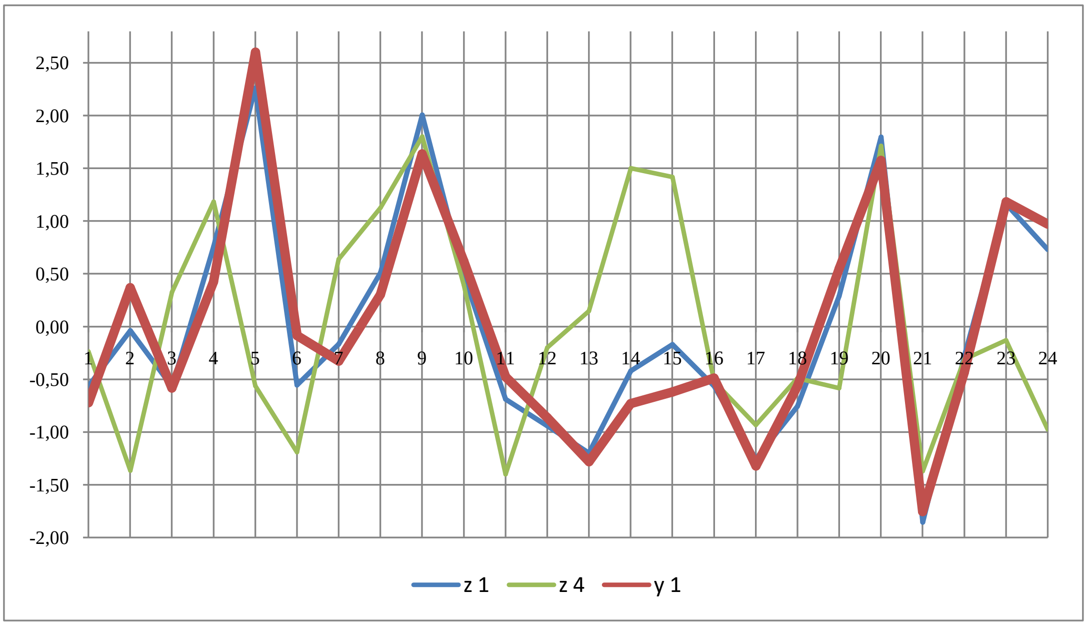

Рисунок 13. Взаимная динамика переменных z_1,y_1

$z_1 = y_1*0.9698+ y_2*0.0000+ y_3*0.0146+ y_4*0.2435+ y_5*0.0001$

$z_4 = y_1*0.2439+ y_2*0.2411+ y_3*0.1276+ y_4*0.8600+ y_5*0.3556$

y_1, i=1,…,24 (Таблица 3)

Визуализация взаимосвязанных динамик изменчивостей показателей климата и показателей негативных видов деятельности человека

Ниже приведены динамики взаимных связей собственных изменчивостей неизмеряемых показателей изменений климата и показателей негативных последствий для деятельности человека.

Наглядные графические иллюстрации динамик значений показателей показывают адекватность реальным связям в системе «изменение климата - природные и хозяйственные последствия». Описание взаимных динамик, для наглядности сгруппированных по 2, 3, 4, 5 штук показателей климата и деятельности человека следующее.

На Рисунках 5-13 в модельных формулах коррелированных z-переменных, влияющих нна не коррелированные модельные y-факторы $y_1,…,y_5$, модель выявила присутствие y-переменной y_5 (отсутствовавшей в исходных данных модели) со слабыми типами: (**$y_{i5}*0.1191$, $y_5*0.1191$, $y_5*0.1191$**). в z-переменной z_{i3}, (**$y_5*0.0048$, $y_5*0.0048$,** $y_5*0.0048$) в z-переменной z_{i2}. Модель выявила отсутствие y-переменной y_5 (**$y_5*0.0001$**) в z-переменной z_{i1}. Но модель выявила мало заметное присутствие y-переменной y_5 (**$y_5*0.0001$**) в z-переменных, z_{i4},(**$y_5*0.3556$, $y_5*0.3556$, $y_5*0.3556$**), z_{i5} (**$y_5*0.9116$**). Эти мало заметные модельные значения также поставляют собой числовую информацию, обосновывающую извлеченные знания об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков. Требуется впредь строго рассматривать подфакторы смыслов смысл(z_4)=«увеличение степени ущерба экологическим системам и биологическому разнообразию в них (что повлечет за собой сокращение возможностей в отношении обслуживания, обеспечения средств к существованию и сокращение доходов), смысл(z_5)= «отклонение от 0 вправо (увеличение) относительного уровня (подъема уровня моря), вызванным ожидаемым повышением температуры». Практический вывод: предложить министерству экологии создать учреждение с функциональной обязанностью: раннее обнаружение скрытых следов случайной катастрофы, аварии, землетрясения, больших паводков и уведомление госорганов об этих скрытых следах.

На рисунках Все динамики значений изменчивостей пар (троек, четверок) переменных визуально показывают существенную роль некоторых z-переменных z_1, z_2, z_3, z_4, z_5 соответственно на y-переменные y_1, y_2, y_3 (Рисунки 8,9,10-13). На y-переменную y_4 сильно и совместно влияют z-переменных z_4, z_5, а на y-переменную y_5 аналогично сильно влияют z-переменные z_1, z_4, z_5 (Рисунки 5,6,9,13). Рисунок 6 ясно показывает взаимные динамики приведенных в выводах переменных z_4, z_5,y_4, где значения z-переменных $z_{i4}=y_{i1}*0.2439+y_{i2}*0.2411+y_{i3}*0.1276+y_{i4}*0.8600$ $y_{i5}*0.3556$, $z_{i5}=y_i1*0.0003+y_{i2}*0.0090+y_{i3}*0.1836+y_{i4}*0.3676+$ $y_{i5}*0.9116$, зависят от случайных значений y-переменных y1, …, y_5, i=1,…,24, из столбцов матрицы $Y_{m5}= U_{m5}\Lambda^{1/2}{}_{55}$[9]

Заключение

Извлечение цифровых знаний из числовых модельных данных по математически введенным индикаторов присутствия знаний позволило нам не использовать мозаику индикаторов, при допустимых значениях наших индикаторов найти матрицу C_{55} собственных векторов и матрицу собственных чисел Λ_{55}=diag(0.9784, 0.7080, 1.3301, 1.9602, 0.0233). Найден новый обоснованный смысл, обоснованный числовой информацией, обосновывающую извлеченное знание об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков. Фраза смысла конструируется при решении смыслового уравнения с семантической неизвестной переменной смысл(y_5). Вид уравнения: смысл(y_5)=смысл(z_3)*0,1191+смысл(z_4)*0,3556+ смысл(z_5)*0,9116. Осмысление правой части уравнения: происходят слабые (с силой $c^2{}_{15}=(0{,}0001)^2$) колебания температуры (смысл(y_1)), но без колебания (с силой $c^2{}_{25}=(0{,}0048)^2$) уровня осадков (смысл(z_2)). Эта фраза обоснованно намекает на постоянно высокую температуру от сильного пожара. В то же время с силой $c^2{}_{45}=(0{,}3556)^2$ повышается степень роста интенсивности сильных ветров (смысл(z_4)) и наблюдается сильное (с силой $c^2{}_{55}=(0{,}9116)^2$) отклонение от 0 вправо (увеличение) относительного уровня (подъема уровня воды («моря»), подаваемых из пожарных водометов), образовавшегося при гашении водой огней пожара. На долю этого явления (с смыслом(y_5)=«») приходится $\lambda_5/(\lambda_1+\ldots+\lambda_5)$=0.8714/((1.0594+1.0560+0.9933+ 1,0198+0.8714)=17,43% информации, учитываемой моделью. Модель не может использовать 100% информации, она учитывает ту информацию, которая в ней заложена плюс извлеченная ею информация. Остальную информацию надо извлекать из других данных. Модель не может все объяснить, не может показать все возможные симптомы случайно возможной техногенной катастрофы (не предусмотренных бюджетом землятресений, больших паводков) со смылом равным смыслу (y_5)=«годовой уровень при добыче, переработке нефти, газа, землятрясения, больших паводков». Вывод: с вероятностью 0.17 возможна катастрофа, у которой z–факторы z_1,z_2,z_3,z_4,z_5 проявятся с силами $0{,}0001^2$, $0{,}0048^2$, $0{,}1191^2$, $0{,}3556^2$, $0{,}9116^2$. сумма сил проявлений равна 100%. Модель количественно точна в рамках ее исходных данных.

Модельные формулы коррелированных z-переменных, влияющих на не коррелированные модельные y-факторы y_1,…,y_5 оказались эффективными: модель выявила присутствие y-переменной y_5 (отсутствовавшей в исходных данных модели) со слабыми типами: (**y_{i5}*0.1191, y_5*0.1191, y_5*0.1191**). В z-переменной z_{i3}, (**y_5*0.0048, y_5*0.0048,** y_5*0.0048) в z-переменной z_{i2}. Модель выявила отсутствие y-переменной y5 (**y_5*0.0001**) в z-переменной z_{i1}. Но также модель выявила малозаметное присутствие y-переменной y_5 (**y_5*0.0001**) в z-переменных, z_{i4}, (**y_5*0.3556, y_5*0.3556, y_5*0.3556**), z_{i5} (**y_5*0.9116**). Эти мало заметные модельные значения также поставляют собой числовую информацию, обосновывающую извлеченные знания об скрытых следах случайной катастрофы, аварии, землятрясения, больших паводков. Модель требует: впредь строго рассматривать подфакторы смыслов смысл(z_4)=«увеличение степени ущерба экологическим системам и биологическому разнообразию в них (что повлечет за собой сокращение возможностей в отношении обслуживания, обеспечения средств к существованию и сокращение доходов), смысл(z_5)= «отклонение от 0 вправо (увеличение) относительного уровня (подъема уровня моря), вызванным ожидаемым повышением температуры».

Из данной работы модели имеем практический вывод: предложить министерству экологии создать учреждение с функциональной обязанностью: раннее обнаружение скрытых следов случайной катастрофы, аварии, землетрясения, больших паводков и уведомление госорганов об этих скрытых следах.

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Contents

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