GLOFCA PROJECT
«Reducing vulnerabilities of populations in the Central Asia region from glacier lake outburst floods in a changing climate»

Report
on the results of maintenance of Adygene station:
1. Duty at the station
2. Equipping the station with additional instruments
3. Maintenance, current repairs and support of station operability

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Content

Introduction

From 2004 to 2011, specialists from the Czech Republic provided significant assistance to hydrogeologists in Kyrgyzstan in the field of ground-based surveying of mountainous outburst prone lakes. They worked in Kyrgyzstan as part of a joint Czech-Kyrgyz project, most of which was funded by the Czech Republic as humanitarian aid to developing countries. This assistance was aimed at developing methodologies for studying lakes and establishing their monitoring systems.

Within the framework of the joint Kyrgyz-Czech project, comprehensive studies of lakes were conducted in 20 of the most prone mountain valleys to mudflows. After its first phase, which was completed in 2006, Czech and Kyrgyz specialists came to one very important conclusion: monitoring of mountain lakes and qualitative forecasting of their development requires a whole set of parameters, which can be obtained through continuous observations at specially equipped high-altitude stations. At the same time, it is very important that the station provides conditions for continuous residence of specialists who will conduct observations, analyze the gathered data, and draw accurate conclusions. Therefore, the following decision was made: during the second phase of the Czech-Kyrgyz project, to build a high-altitude lake-glaciological station. Of course, for a comprehensive understanding of the development of mountain lakes and glaciers in Kyrgyzstan, one station is insufficient; it requires 10-15 such stations. However, due to limited funding allocated by the Czech Government, only one station was built. It was intended not only to be the first of its kind in Kyrgyzstan but also a model station that could serve as a basis for setting up similar stations in other valleys.

1. Adygene station structure

In 2008, under the leadership of M. Cherny from the Czech Republic and S.A. Erokhin from Kyrgyzstan, a high-mountain lake-glaciological station called "Adygene" was built in the basin of the Ala-Archa River. This station enabled a detailed study of the most hazardous moraine-glacial lakes. This station was built using funds from the Czech Republic and was donated to the Kyrgyz Republic to effectively conduct monitoring of outburst prone high-mountain lakes.

When choosing the location for the station among all possible options, the preference was given to the valley of the Ala-Archa River. The advantages of this valley over the others were as follows.

1. The Ala-Archa Valley is characterized by increased susceptibility to mudflows compared to other valleys in the Northern Tien Shan. Activity of debris flows here is largely due to the outburst of lakes and intraglacial reservoirs.

2. Bishkek, the capital of Kyrgyzstan, is located at the mouth of the valley. The city is situated along the course of the Ala-Archa River, which carries floodwaters threatening to inundate the city's adjacent areas.

3. In the lower part of the Ala-Archa River valley there is a recreation area for residents of Bishkek and numerous guests of Kyrgyzstan. During warm spring and summer days, tens of thousands of people come here for leisure. The president of the Kyrgyz Republic's country house is also located in this area.

The main requirements for the station location were as follows:

1) The station should be located near mountain lakes and glaciers to enable round-the-clock and year-round monitoring of these features.

2) There should be access to the station, even if only by foot and without the use of special climbing equipment;

3) There should be a location nearby the station suitable for helicopter landings.

After surveying all the mountain lakes and glaciers in the Ala-Archa Valley, a location for building the station was chosen. The chosen site was an extensive glacial cirque in the upper reaches of the Adygene River Valley (fig.1), a left tributary of the Ala-Archa, situated at an altitude of 3670 meters, approximately 60 kilometers southwest of the city of Bishkek (fig.2).

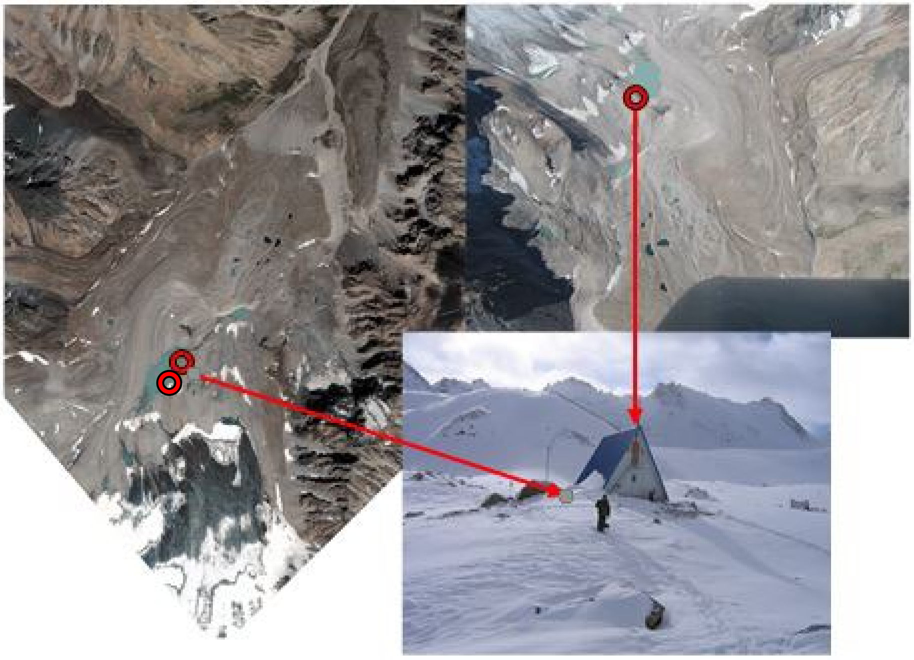


Fig. 1. As a result of the retreating glacier, an extensive moraine-glacier complex has formed, hosting numerous lakes on its surface. The Adygine Station is situated between these lakes, near the exposed section of the Adygine Glacier.

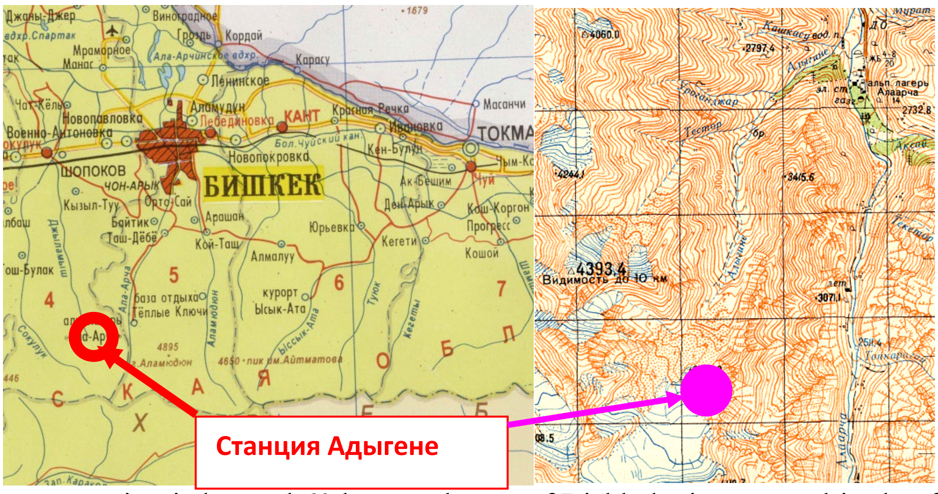


Fig. 2. Adygene station is located 60 km southwest of Bishkek city, at an altitude of 3670m, in the upper valley of the Adygene River, a left side tributary of the Ala-Archa River

Near the location of the station (0.3-0.5 km away), there is a terminus of the Adygine Glacier (Fig. 3). Currently, the glacier is retreating and breaking apart into separate tongues at its terminus, divided by medial moraines. However, it still covers a considerable area (about 2 sq km), occupying the entire upper part of the glacial cirque.

Fig. 3. The Adygine Glacier is retreating and breaking into separate tongues (Photo A). However, it still covers a significant area in the upper part of the glacial cirque (Photo B).

The station houses are located on the shore of the largest of the Adygene lakes (Fig.4). It is so called Big Adygene. When choosing a site for building the station houses, the possibility of subsidence of the foundation during the melting of frozen moraine soils and buried ice was taken into account. Therefore, the houses are installed on rocky soils, covered with a thin cover of moraine (1-1.5 m). To avoid disrupting the natural temperature regime, the foundations of the houses are based on piles dug into the frozen ground at 0.5-1 meter. The height of the piles above the ground is 0.5-0.7 meters.

Fig.4. Location of the houses of the Adygene station on the shore of Lake Bolshoye Adygene

For heating and warming the station, two energy sources are used: solar panels and a gasoline generator. There are plans to resume the operation of a wind generator.

3. Work program of Adygene station

1. *Regular regimen observations.* Daily observations are conducted by duty officers. The observation set includes the following (Figure 5.16)

- air temperature measurement: maximum, minimum, urgent every three hours;

- observations of precipitation and measurement of its amount in each case of precipitation;

- observations of wind direction and speed, measurements every three hours;

- cloud observations, recording changes every three hours;

- measurement of snow cover height at the observation site every three hours during daytime;

- in May - June, measuring the height of the water level and its temperature in Lake Bolshoye Adygen every three hours;

- in June – September, daily inspection of the Small Lakes of Adygene and recording changes in their volume; in the event of an increase in the volume of one of the lakes, the height of its level is measured daily at 16.00.

- in June - September, the height of the water level and its temperature in the Periglacial Lake Adygene were measured every three days at 15.00.

Fig. 5. Air and water temperature measurements under the ice of the frozen lake

Fig. 6. Cloud observations and snow cover survey

2. Periodic observations and studies. They are carried out by specialists who go up to the station for a while to carry out certain works. Most works are scheduled for the warm months of May-September, when glaciers open from snow and lakes fill. The number and timing of works, as well as their executors, change over time. In 2010, work was carried out under the following programs:

- observations of the retreat of the border of the open part of the Adygen glacier as a result of its reduction (Fig. 7).

- observations of a decrease in the thickness and volume of the Adygene glacier as a result of its reduction;

- installation of 2 automatic weather stations at altitudes of 3600 and 3900m, their activation and maintenance (Fig. 8);

- installation of three automatic thermometers for measuring air temperature on the Adygen glacier (1 thermometer) and the slopes of the mountain frame (2 thermometers), at altitudes of 3600, 3900 and 4000 m, activation of thermometers and their maintenance;

- Installation of an automatic water level gauge at Lake Bolshoye Adygene, its activation, and maintenance;

- Installation of 5 automatic thermometers to measure temperature fluctuations at the near-surface layer, at a depth of 10-15 cm. The thermometers are installed in different parts of the Adygene moraine-glacial complex. Activation and maintenance of these thermometers;

- bathymetric survey of Adygen lakes in August, during the period of their maximum filling.

Fig. 7. Installing benchmark stakes on the Adygene Glacier

Fig. 8. Installation of automatic weather stations and GPS navigation instruments

Thanks to the data obtained from the station, the outbursts of Lake Tez-Tor in 2012, Lake Chelektor in the Nooruz River basin in 2017 and Lake Akpai in the Sokuluk River basin in 2021 were forecasted. Further development of stationary observations of high mountain lakes is very important not only as an example of successful local monitoring, but can also be applied at the regional level.

4. Observations on lake development in the Adygene moraine-glacial complex

Over the last 46 years, 17 new moraine-glacial lakes[1,2] have appeared. Among them are 3 lakes are of the subtype of intramoraine depressions: 2D, 4D and 5D, one lake 6D of the subtype of slope depressions and 13 lakes of the thermokarst subtype (Fig. 9). Each lake goes through both stages of rapid growth and a stable phase of its development[1].

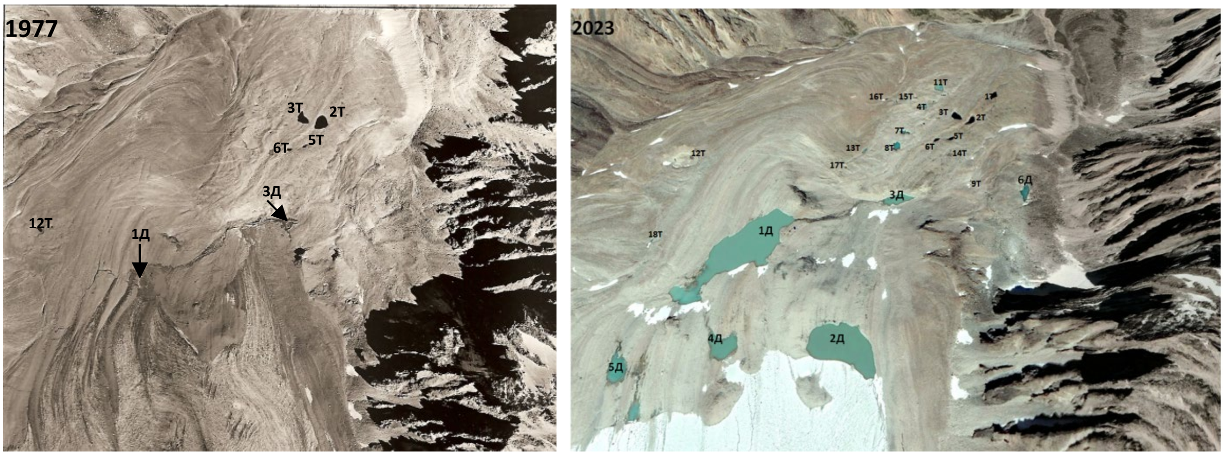


Fig. 9. A section of the moraine-glacial complex of Adygene, on which 17 new moraine-glacial lakes have appeared over the past 46 years. Among them 3 lakes are of the subtype of intramoraine depressions: 2D, 4D and 5D, one lake 6D of the subtype of slope depressions and 13 lakes of the thermokarst subtype.

For a better understanding of the development processes of high-altitude lakes and assessing the threat of their outburst, annual bathymetric measurements are conducted at the most actively evolving outburst prone lakes—Adygene Bolshoe and Adygine Prilednikovoe—at the Adygine station. The latest measurements taken in 2023 (Figures 10 and 11) indicate that the Adygine Prilednikovoe lake has nearly reached its development peak. Further increase of the lake area will be insignificant as the moraine has already been exposed under the retreating glacier and there will be nowhere for the lake to grow further, increase of the lake volume is possible only due to thawing of the lake bottom.

Bathymetric measurements were conducted using the Deeper Pro+ echo sounder, and the data were processed in the ArcGIS software using the Kriging interpolation method. Free available services were used to collect satellite images from different years. The images were processed in ENVI and SNAP software.

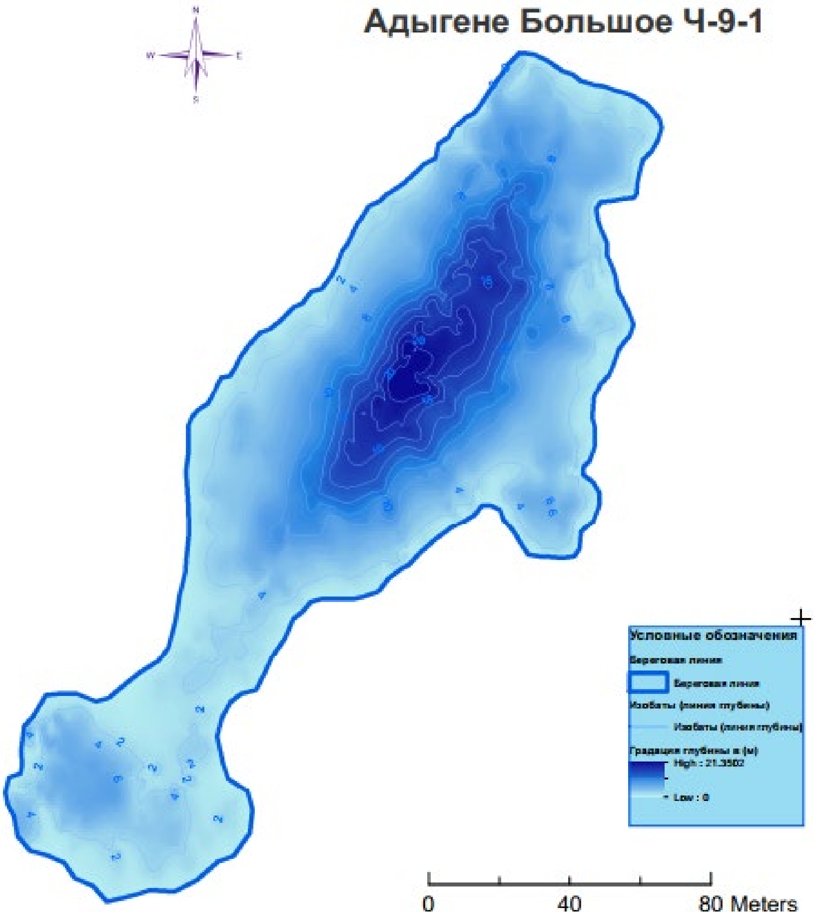


Fig. 10. Bathymetric map of Lake Adygene Bolshoe, 2023

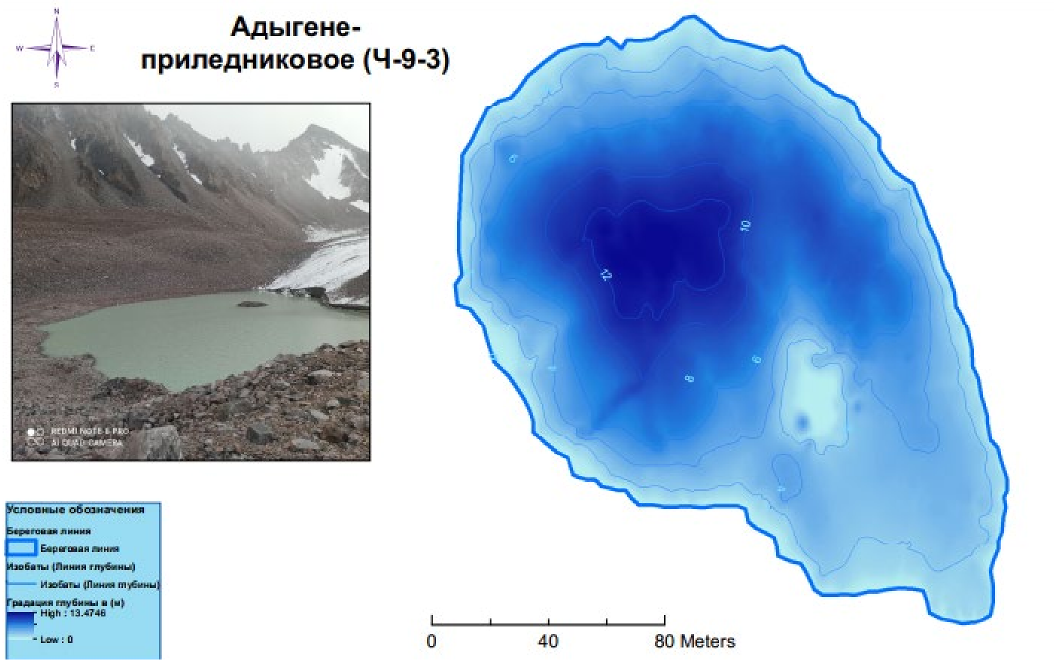


Fig. 11. Bathymetric map of Lake Adygene Prilednikovoe, 2023.

During the observations at the Adygine station, the phenomena of filling and draining of lakes have been repeatedly observed. For instance, thermokarst lake №T9 fills up every three years. Последний раз это произошло в 2022г (рис.12). The last time it happened in 2022

(Fig.12). Its volume increased up to 30 thousand m^3. There was a hazard of catastrophic outburst of the lake through underground channels with transformation of the outburst flow into mudflow. However, the capacity of underground channels was limited to 1-3 m^3/sec. Therefore, the outburst was gradual. It began on July 20th. Initially, the lake level dropped by 104 cm within the first day, followed by a 200 cm decrease on the second day, and 112 cm on the third. Then, the decline started to slow down, reaching 60 cm on the fourth day, 45 cm on the fifth, and only 12 cm on the ninth day. By the twelfth day, the level stabilized.. This pattern of outburst indicates that the drainage channel's capacity during the outburst depends on the water pressure of the lake, namely its depth. As the lake's depth decreases (the level falls), the water pressure decreases, affecting the drainage channel's capacity, even though its cross-section remains unchanged.

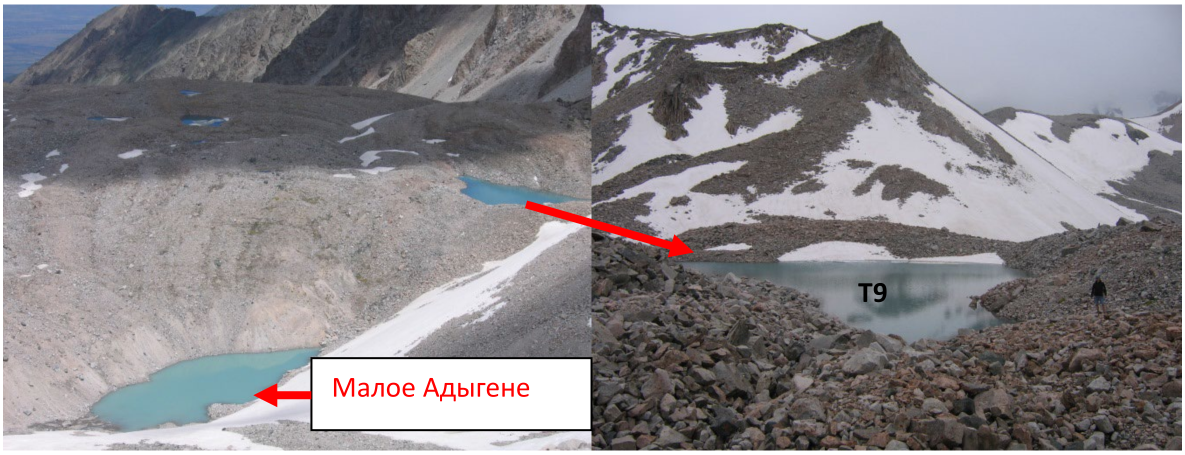


Fig. 12. Non-stationary Lake № 9, last filled in 2022 and burst on 20.07.2022.

5. Analysis of meteorological parameters at Adygene station

At the station, in addition to monitoring the state and development of lakes, observations of key meteorological parameters are carried out using automatic weather stations manufactured by Fiedler. The main objective of the measurements is to assess the primary climatic trends in the high-altitude zone. Figures 13 and 14 show the daily temperature and precipitation data collected from the automatic station located 100 meters from the main station.

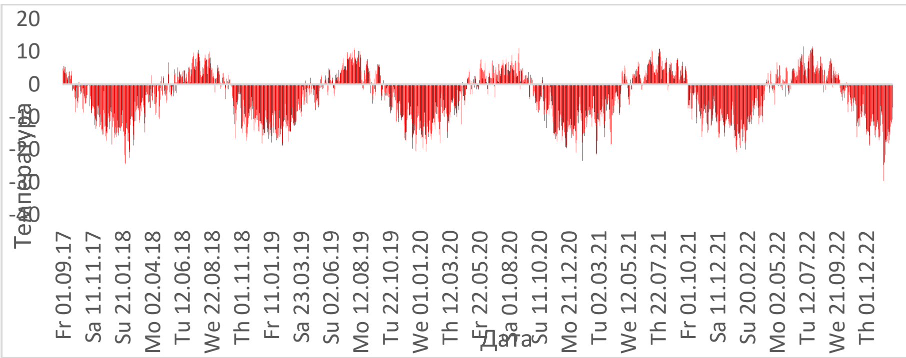


Fig. 13: Air temperature, at a height of 2 m

The main peak of precipitation occurs during the first decade of August from 2020 to 2022, although 2018 and 2019 show a precipitation peak during the first decade of July (Figure 14).

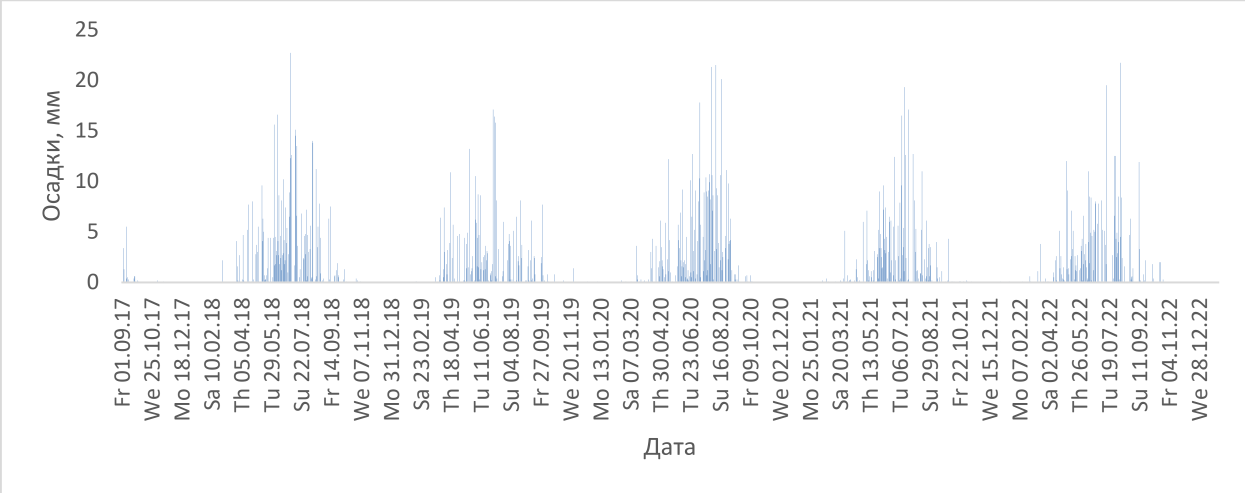


Fig. 14: Amount of liquid precipitation, mm

The graph showing the temperature fluctuations in the soil layer correlates well with the air temperature and demonstrates peaks on the same dates, except for the absence of soil freezing during the summer period when the temperature drops below zero (Figure 15).

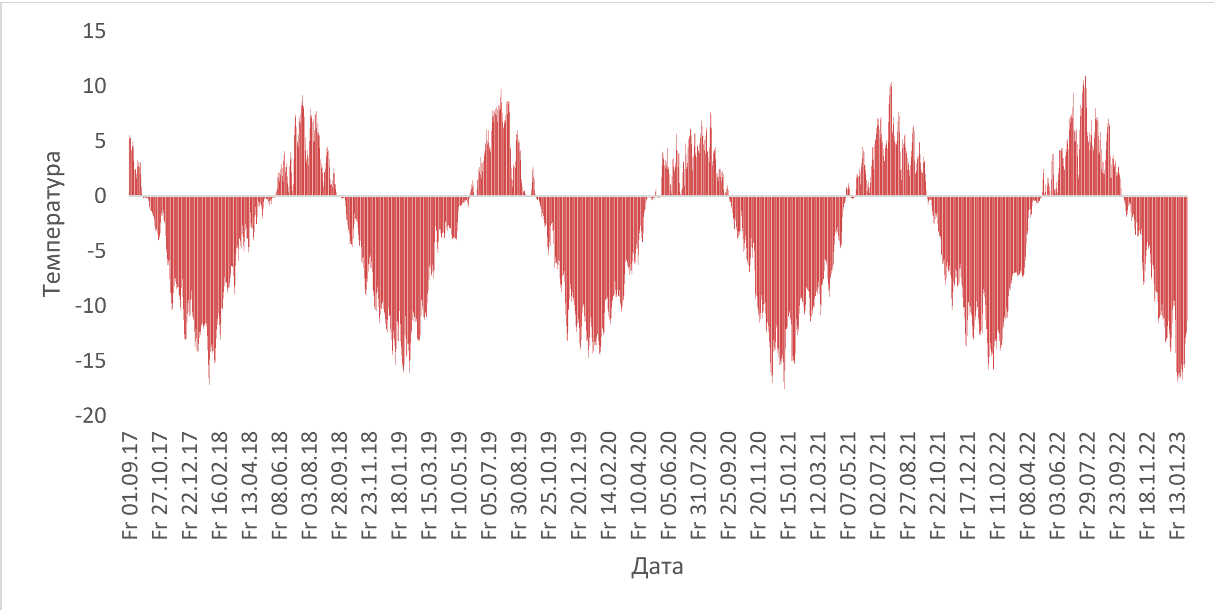


Fig. 15: Soil temperature, at a depth of 30 cm

Fig. 16 (A-D) shows a graph of water level fluctuations in Lake Adygene Bolshoe during the summer months (June, July, August, September) from 2013 to 2016.

The fluctuation in the water level in the lake during one season is a very important indicator, as it shows the degree of filling of the lake and reflects the melting factor. Figure 17 shows the water level in Lake Adygene Bolshoe during 2023.

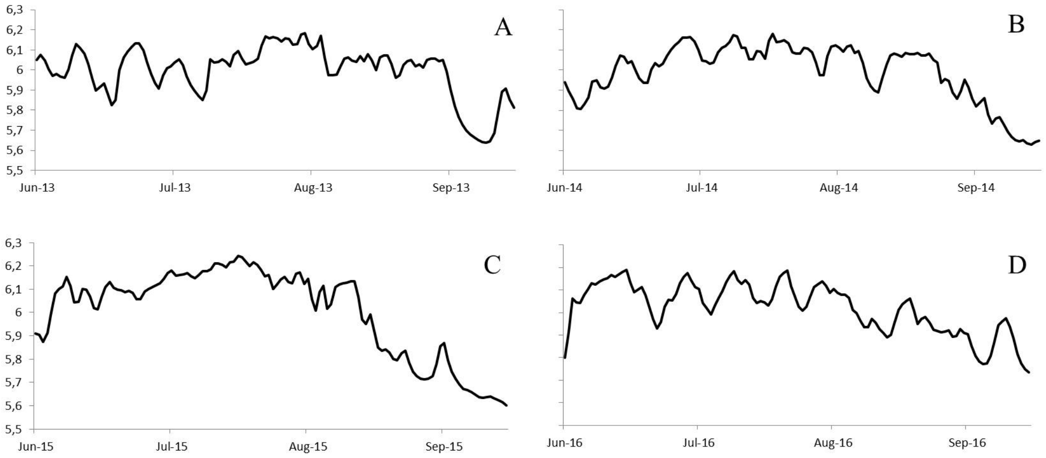


Fig.16. Level fluctuation in Lake Adygene Bolshoe

The fluctuation in the water level in the lake during one season is a very important indicator, as it shows the degree of filling of the lake and reflects the melting factor. Figure 15 shows the water level in Lake Adygene Bolshoe during 2023.

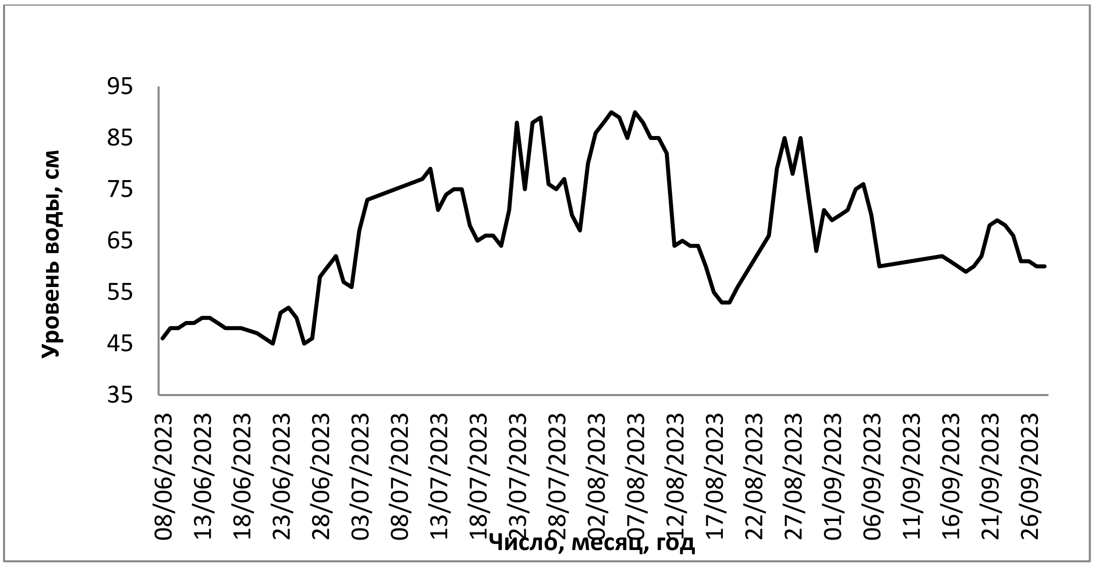


Fig.17. Graph of water level in Lake Adygene Bolshoe in 2023

6. Measuring ice thickness on lakes

With the onset of the cold period, when night and day temperatures remain negative - late September, early October (for altitudes above 3000 m asl) and the appearance of ice cover on high-mountain lakes, the water level in these lakes begins to decrease. The inflow of water from glaciers into the lake ceases. Surface runoff from the lakes Adygene (namely Bolshoe and Prilednikovoe) disappears with the appearance of ice, but a portion of water continues to drain through underground drainage channels until they freeze over and stop allowing water passage. In October, the ice thickness on the lakes is 40 cm and then it continues to increase. In the coldest months (January, February) it does not exceed 90 cm.

Measurements to determine the thickness of the ice on the lakes during the period of solid ice cover are conducted using a measuring tape in the middle of the lakes. Measurements are taken twice a day, in the morning and in the evening, to obtain the average value. These observations were carried out during the winter period to establish the maximum depth of ice freezing on Lake Adygene Bolshoe (D1) (Figure 18).

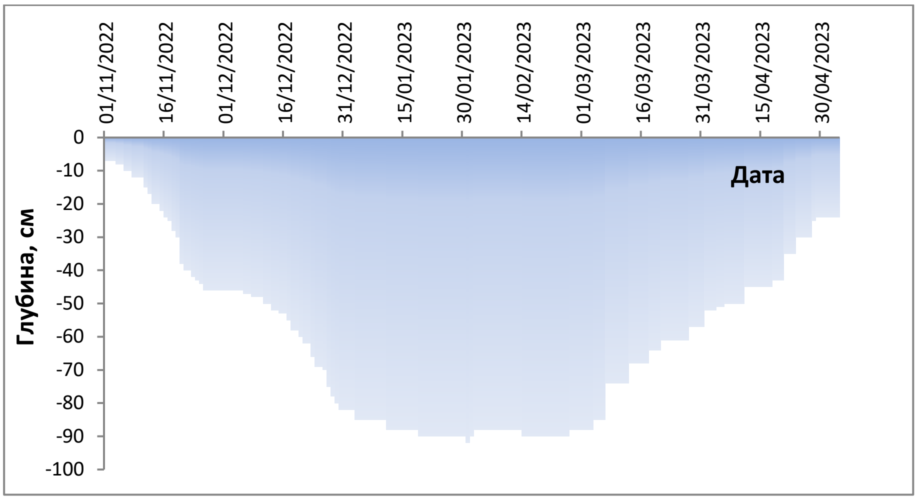


Fig. 18. Ice freezing depth at Adygene Bolshoye Lake

The anomaly of liquid water is associated with its uneven change in density when the temperature changes. It has long been established that water has its highest density at a temperature of +4°C. When the water in a reservoir cools, the denser surface layers sink, resulting in the effective mixing of warmer and lighter deep water with the surface layer. Submergence of the surface layers occurs only as long as the water in the reservoir cools to +4°C. Beyond this threshold, the density of the colder surface layers doesn't increase but rather decreases, causing them to float without further submersion. When temperatures drop below 0°C, these surface layers transform into ice.

7. Measuring water temperature on the Prilednikovoe Lake Adygene (D2)

A temporary forecast of the outburst hazard of high-mountain lakes seems to be a difficult task, since clear criteria have not yet been developed that would allow us to give a reliable, clear forecast. While a rise in the water level to a certain critical level in the lake, as a criterion indicating that the lake is at an outburst stage, it does not provide a complete picture.

In recent years, the primary method for assessing the potential hazard of outburst of high-mountain lakes has been the remote sensing technique using satellite imagery, which only allows for the detection of water level increases in lakes. It is necessary to introduce new quantitative criteria to provide a qualitative assessment of the outburst hazard of moraine-glacial lakes and, accordingly, improve the forecast of outburst hazard.

As can be seen in Figure 19, the temperature difference in different parts of the lake is only one degree Celsius. The given temperature map for a depth of 2 meters (Fig. 19) gives a complete picture of the temperature distribution in the lake. Thus, the coldest water is concentrated at the site of the main tributary, where the largest jet stream from the glacier is observed, the highest water temperature is recorded near the banks. Melting is also observed along the surface of the entire glacier in the form of small streams. The temperature map distinctly highlights cold areas near the southern shore and warmer shallow water zones near the northern shore. Particularly noticeable are the cold areas at the mouths of the melting glacier streams.

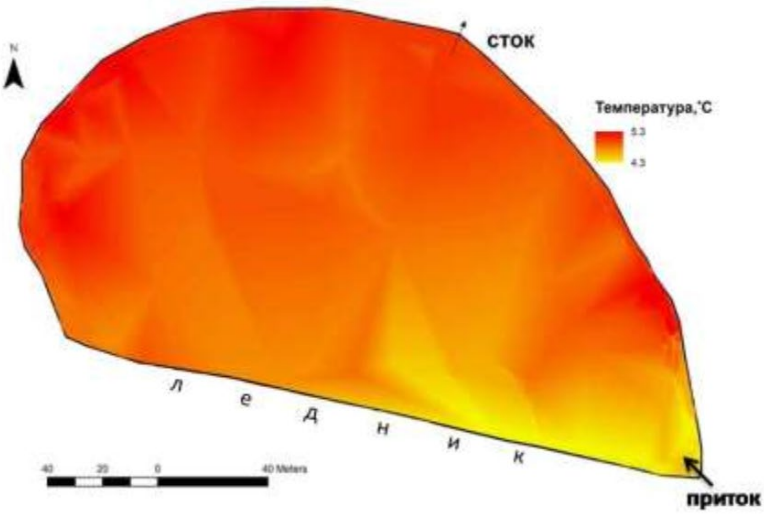


Fig. 19: Map of water temperature at a depth of 2 meters on a Prilednikovoe lake

Higher temperatures at the shores are attributed to the heating of the water due to solar energy. Judging from Figure 20 and the absence of abnormal areas with significantly increased water temperatures, it can be inferred that the water distribution at this depth is uniform.

Figure 20 shows the average water temperatures at various depths in the lake. The warmest layer is observed at a depth of 1-2 meters, followed by a decrease in temperature down to 6 meters, with a slight increase in temperature at the 10-meter depth.

The graph in Figure 20 clearly shows a uniform decrease in water temperature with depth. There is a slight increase in water temperature at a depth of 10 meters, followed by a decrease in temperature beyond that point. While this anomaly is minor, the presence of such anomalies suggests the possibility of their occurrence at other depths as well.

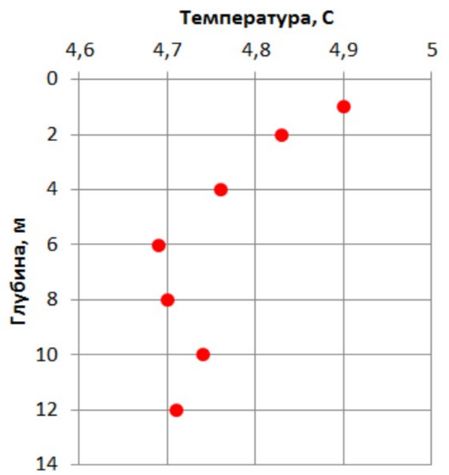


Fig. 20: Average temperature values at different depths

Additional monitoring data for 2023

8. Maintenance of Adygene station.

1. Technical maintenance of the Adygene station was partially carried out in August-September 2023. Two large solar panels, two large batteries, and gas cylinders were delivered to the station. As a result, lighting was restored at the station, and the possibility of charging devices with electricity became available. Due to late funding for the second part of the work, the main components of the station's power unit were purchased in October-November when delivery to the station became problematic due to snowdrifts. A total of 10 solar panels with metal frames, 4 large and 6 small batteries, and a wind generator were purchased. All these devices are planned to be delivered to the station and put into operation in May-July 2024.

9. Hydrometeorological monitoring data for 2023

Additionally, Report 8 provides the following data processed at the end of 2023.

9.1. Data on water level fluctuations in the Adygene -Bolshoe Lake

Table 1

Date	Level, cm		Date	Level, cm		Date	Level, cm	
08.06.2023	40		**20.07.2023**	65		**27.08.2023**	85	
09.06.2023	44		**21.07.2023**	66		**28.08.2023**	78	
10.06.2023	46		**22.07.2023**	66		**29.08.2023**	85	
11.06.2023	48		**23.07.2023**	64		**30.08.2023**	74	
12.06.2023	48		**24.07.2023**	71		**31.08.2023**	63	
13.06.2023	49		**25.07.2023**	88		**01.09.2023**	71	
14.06.2023	49		**26.07.2023**	75		**02.09.2023**	69	
15.06.2023	50		**27.07.2023**	88		**03.09.2023**	70	
16.06.2023	50		**28.07.2023**	89		**04.09.2023**	71	
17.06.2023	49		**29.07.2023**	76		**05.09.2023**	75	
18.06.2023	48		**30.07.2023**	75		**06.09.2023**	76	
20.06.2023	48		**31.07.2023**	77		**07.09.2023**	70	
21.06.2023	48		**01.08.2023**	70		**15.09.2023**	60	
22.06.2023	47		**02.08.2023**	67		**16.09.2023**	62	
23.06.2023	46		**03.08.2023**	80		**17.09.2023**	61	
24.06.2023	45		**04.08.2023**	86		**18.09.2023**	60	
25.06.2023	51		**05.08.2023**	88		**19.09.2023**	59	
26.06.2023	52		**06.08.2023**	90		**20.09.2023**	60	
27.06.2023	50		**07.08.2023**	89		**21.09.2023**	62	
28.06.2023	45		**08.08.2023**	85		**22.09.2023**	68	
29.06.2023	46		**09.08.2023**	90		**23.09.2023**	69	
30.06.2023	58		**10.08.2023**	88		**24.09.2023**	68	
01.07.2023	60		**11.08.2023**	85		**25.09.2023**	66	
02.07.2023	62		**12.08.2023**	85		**26.09.2023**	61	
03.07.2023	57		**13.08.2023**	82		**27.09.2023**	61	
04.07.2023	56		**14.08.2023**	64		**28.09.2023**	60	
11.07.2023	67		**15.08.2023**	65		**29.09.2023**	60	

12.07.2023	73		**16.08.2023**	64		**29.09.2023**	60	
13.07.2023	77		**17.08.2023**	64				
14.07.2023	79		**18.08.2023**	60				
15.07.2023	71		**19.08.2023**	55				
16.07.2023	74		**20.08.2023**	53				
17.07.2023	75		**24.08.2023**	56				
18.07.2023	75		**25.08.2023**	66				
19.07.2023	68		**26.08.2023**	79				

A visual representation of the amplitude of fluctuations in the water level of Lake Adygene-Bolshoe in 2023 is provided by the level fluctuation graph (Fig. 21).

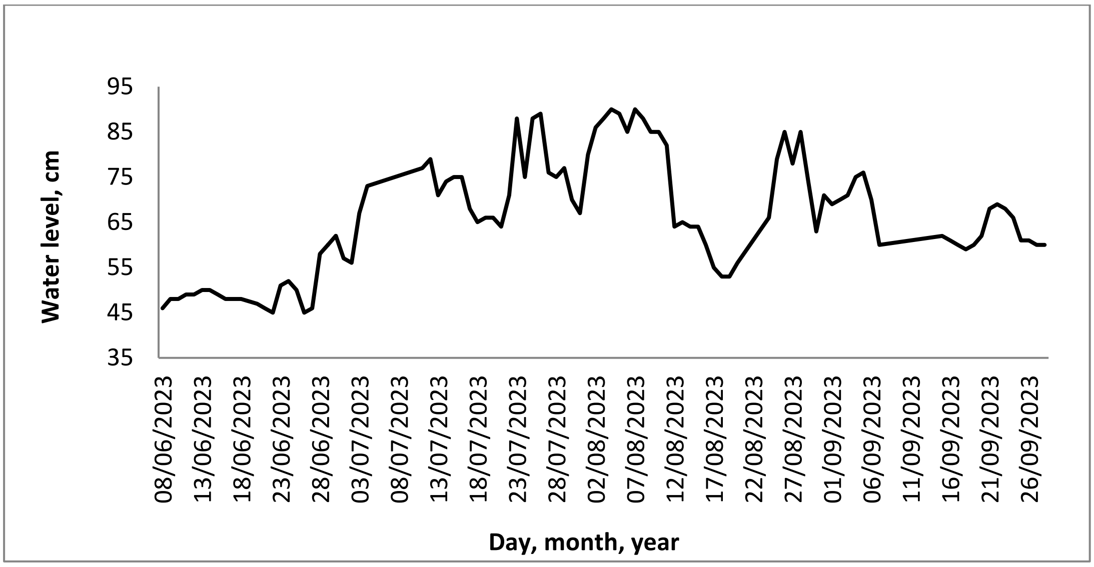


Fig. 21.Graph of Lake Adygene-Bolshoye level fluctuation in 2023

9.2.Data on air temperature fluctuations at Adygene station

Air temperature measurements at the Adygene station were taken at a height of 2 meters using three thermometers: regular, maximum, and minimum. Measurements were taken every three hours, and then the average value for each of the measured parameters was calculated (Table 2). The measurements were conducted during the duty period at the station and are a crucial part of the monitoring system for hazardous outburst prone lakes.

Table 2

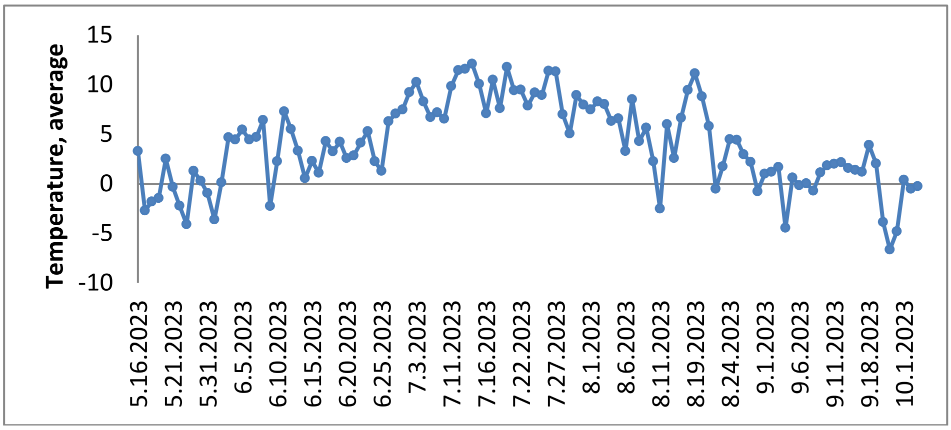
Date	Average	мax	Min
5.16.2023	**3,3**	**6,9**	**1,7**
5.17.2023	**-2,7**	**2,25**	**-3,2**
5.18.2023	**-1,8**	**3,1**	**-4,3**
5.19.2023	**-1,45**	**1,6**	**-3,15**
5.20.2023	**2,53**	**3,2**	**-0,63**
5.21.2023	**-0,33**	**2,4**	**-2,43**
5.22.2023	**-2,23**	**-0,85**	**-2,98**
5.23.2023	**-4,1**	**-2,4**	**-5,4**
5.29.2023	**1,3**	**-1,3**	**-6,1**

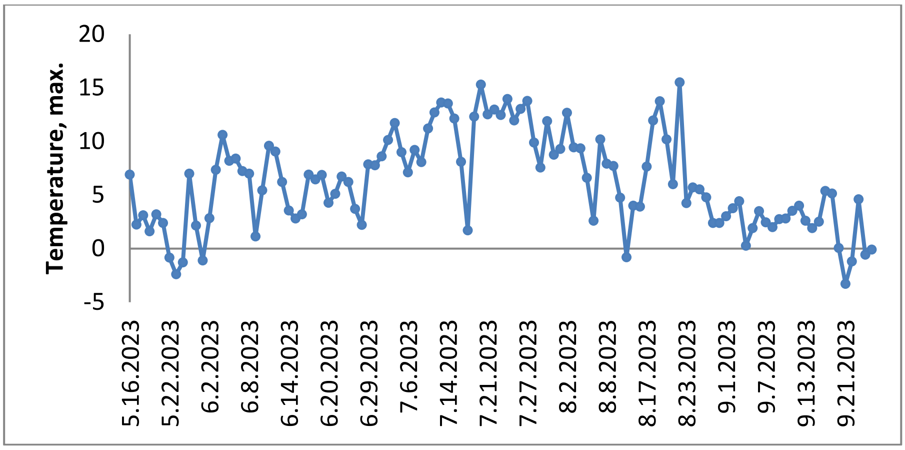
5.30.2023	0,3	7	-4,35
5.31.2023	-0,93	2,16	-4,83
6.1.2023	-3,6	-1,12	-5,42
6.2.2023	0,15	2,84	-3,16
6.3.2023	4,68	7,34	1,52
6.4.2023	4,46	10,6	3,1
6.5.2023	5,45	8,18	-0,2
6.6.2023	4,46	8,4	2,2
6.7.2023	4,72	7,22	2,16
6.8.2023	6,42	6,98	3,84
6.9.2023	-2,26	1,12	-2,9
6.10.2023	2,28	5,43	0,18
6.11.2023	7,3	9,58	4,16
6.12.2023	5,52	9,06	3,74
6.13.2023	3,32	6,22	1,38
6.14.2023	0,56	3,54	-0,42
6.15.2023	2,3	2,8	-2,1
6.16.2023	1,1	3,2	-0,2
6.17.2023	4,3	6,9	1,08
6.18.2023	3,28	6,46	1,4
дата	Ср	мах	Min
6.19.2023	4,24	6,88	1,76
6.20.2023	2,58	4,28	1,38
6.21.2023	2,85	5,1	-1,6
6.22.2023	4,12	6,72	3,38
6.23.2023	5,3	6,22	3,66
6.24.2023	2,28	3,7	-0,2
6.25.2023	1,3	2,2	-1,6
6.29.2023	6,3	7,85	3,98
6.30.2023	7,08	7,78	4,7
7.1.2023	7,5	8,6	4,84
7.2.2023	9,23	10,13	5,56
7.3.2023	10,26	11,7	8,82
7.4.2023	8,3	9	6,5
7.6.2023	6,7	7,1	3,4
7.9.2023	7,2	9,2	3,4
7.10.2023	6,55	8,08	1,6
7.11.2023	9,84	11,22	8,82
7.12.2023	11,46	12,7	7,94
7.13.2023	11,6	13,62	4,6
7.14.2023	12,1	13,55	3,8
7.15.2023	10,08	12,12	3,82
7.16.2023	7,1	8,1	3,3
7.18.2023	10,5	1,7	4
7.19.2023	7,62	12,3	5,93

7.20.2023	11,78	15,3	9,28
7.21.2023	9,44	12,52	7,96
7.22.2023	9,5	12,98	6,46
7.23.2023	7,88	12,46	8,8
7.24.2023	9,2	13,96	8,1
7.25.2023	8,94	11,96	7,38
7.26.2023	11,4	13,02	7,76
7.27.2023	11,32	13,78	8,86
7.28.2023	7	9,9	5,7
7.29.2023	5,06	7,56	3,12
7.30.2023	8,94	11,89	3,78
7.31.2023	7,96	8,74	6,42
8.1.2023	7,5	9,28	5,32
8.2.2023	8,3	12,68	7,04
8.3.2023	8,04	9,44	5,94
8.4.2023	6,32	9,36	4,8
8.5.2023	6,6	6,6	2,8
8.6.2023	3,3	2,6	3,3
8.7.2023	8,52	10,2	5,7
8.8.2023	4,3	7,92	3,98
дата	Ср	мах	Min
8.9.2023	5,64	7,72	2,88
8.10.2023	2,28	4,76	1,64
8.11.2023	-2,5	-0,8	-2,9
8.15.2023	6	4	2,2
8.16.2023	2,58	3,92	2,02
8.17.2023	6,66	7,66	5,54
8.18.2023	9,46	11,96	6
8.19.2023	11,12	13,74	7,4
8.20.2023	8,82	10,18	6,06
8.21.2023	5,8	6	2,4
8.22.2023	-0,5	15,5	-0,5
8.23.2023	1,75	4,25	-2
8.24.2023	4,5	5,72	0,9
8.25.2023	4,44	5,54	3,04
8.26.2023	2,96	4,78	1,7
8.27.2023	2,2	2,4	-0,9
8.31.2023	-0,78	2,4	-2,38
9.1.2023	1	3,02	-0,5
9.2.2023	1,2	3,75	-0,3
9.3.2023	1,68	4,42	0,64
9.4.2023	-4,46	0,28	-5,44
9.5.2023	0,62	1,9	-2,68
9.6.2023	-0,14	3,5	-2,12
9.7.2023	0,04	2,44	-2,86

9.8.2023	-0,7	2	-3,08
9.9.2023	1,14	2,76	-2,44
9.10.2023	1,86	2,8	-2,22
9.11.2023	2,02	3,52	-0,94
9.12.2023	2,16	4	0,18
9.13.2023	1,6	2,6	-0,95
9.16.2023	1,4	1,9	-1,6
9.17.2023	1,2	2,5	-1,2
9.18.2023	3,92	5,38	1,32
9.19.2023	2,04	5,14	0,3
9.20.2023	-3,88	0,06	-4,46
9.21.2023	-6,65	-3,3	-7,35
9.30.2023	-4,8	-1,2	-8,3
10.1.2023	0,4	4,6	-2,4
10.2.2023	-0,52	-0,56	-2,4
10.3.2023	-0,24	-0,08	-4,04

A visual representation of air temperature fluctuations at Adygene station in 2023 is given by air temperature graphs (Fig.22).





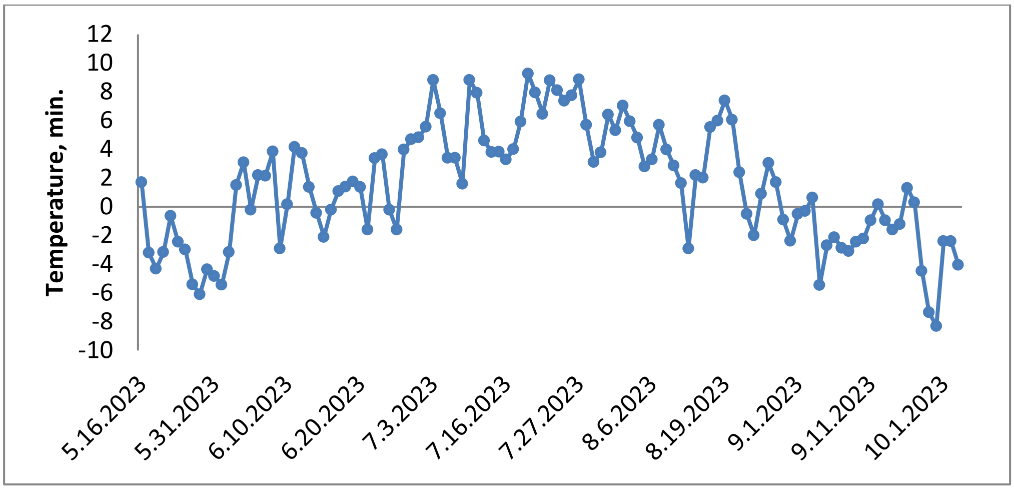


Fig.22. Graphs of air temperature fluctuations at Adygene station in 2023g

Conclusions

For a better understanding of the processes of moraine-glacial lake development, it is necessary to continue their comprehensive study aimed at identifying factors influencing the hazardous nature of high-altitude lakes. Due to limited data in the high-altitude zone, it is necessary to enhance the existing potential of the Adygene lake-glaciological station by expanding the range of research conducted there.

Data on monitoring the water temperature in the lake can be useful for predicting the hazardous outburst period. Further development of understanding this parameter will improve the accuracy of the forecast.

The meteorological parameters measured at the Adygene station are unique because there are not many similar stations in the region, and in Kyrgyzstan, it is the only lake-glaciological station focusing on monitoring potentially hazardous lakes. The data accumulated since 2008 allow for the construction of future models based on historical data. The data from the Adygene station have been used by the Department of Emergency Situations Forecasting Monitoring at the Ministry of Emergency Situations of the Kyrgyz Republic to forecast the hazardous outbursts of high-altitude lakes.

Report 8 presents the results of work and measurements conducted in 2023 (Table 3):

- Bathymetric measurements, which are compared in the report with previous measurements;
- Meteorological measurements and measurements of ice freezing, which were conducted for the first time in 2023 on Lake Adygene;
- Thermal imaging of lakes Adygene-Bolshoy and Adygene-Prilednikovoye, these experiments are unique for the research area;
- Measurements of water level fluctuations in Lake Bolshoy Adygene.

The types of work carried out in 2023 and the results of these works are listed in the table below.

Table 3

Works	Result	Period of performance
Bathymetric measurements of Lake Adygene – Bolshoe	An updated bathymetric map has been built	August, 2023
Bathymetric measurements of Lake Adygene – Prilednikovoe	An updated bathymetric map has been built	August, 2023

Horizontal temperature profiling, Bolshoe Lake	The pattern of temperature changes depending on depth has been studied	September, 2023
Measurement of water temperature in a lake, at a depth of 2 m	A temperature map of Lake Adygene periglacial has been built	September, 2023
Air temperature measurements	Seasonal graphs of air temperature change, including 2023 measurements, were built	Throughout the 2023 field season
Measurements of water level fluctuations in Lake Bolshoye Adygene	A graph was constructed of changes in the water level in the lake during the lake filling season of 2023	Throughout the 2023 field season
Study of ice thickness on Lake Adygene Bolshoye	Unique results were obtained on ice freezing on Lake Adygene	till May, 2023