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Methodology of ground temperature monitoring system development

Denis Frolov[1*], *Andrey* Koshurnikov[1], *Vladimir* Gagarin[1], *Islom* Nabiev[1], and *Ehson* Dodoboev[1]

[1]Lomonosov Moscow State University, Leninskie gory, 1, 119991, Moscow, Russia

Abstract. The paper presents the proposed methodology of ground temperature monitoring, which can be used for geotechnical monitoring of mountainous and northern infrastructure in the areas of seasonal and long-term ground freezing in order to protect these infrastructure facilities from destruction due to seasonal and long-term changes in the bearing capacity of the ground.

1 Introduction

One of the factors determining the stability of mudflow and avalanche -retaining structures in mountainous areas on the slopes is the dynamics of the active layer underlying the foundations. Within the Gissar Range (Tajikistan), the seasonally frozen layer is a very dynamic system, both in engineering and geological terms (development of solifluction and other slope processes) and in the geocryological aspect (its thickness varies almost 2 times in different years depending on snow accumulation conditions). Carrying out regime observations on stationary sites for the state and dynamics of the development of frozen rocks makes it possible to show a fairly complete picture of the geocryological conditions of the study area.

Also, in accordance with recent resolutions of the President and Government of the Russian Federation, a new operational and production unit has been created at the Arctic and Antarctic Research Institute (AARI) - the Center for Monitoring the State of Permafrost. The new division aims to manage the infrastructure of the state permafrost monitoring system, which is due to start in 2023. The center will ensure the organization and operation of a network of observation points, the receipt, analysis and storage of data, the preparation of reference and reporting information and the transfer of information to the Unified State Data Fund on the state of the environment and its pollution. In total, the concept of the monitoring system provides for the equipment of 140 observation points for changes in permafrost, which will be located from the far north to Tuva and the Altai Territory. The points will be located on the basis of Roshydromet stations, which will significantly reduce the cost of the project. The new observation system will allow full-scale monitoring of permafrost, which occupies two thirds of Russia's territory. The first 20 monitoring points are planned to be deployed this year. It is planned to fully deploy the observation system by the end of 2025.

* Corresponding author: denisfrolovm@mail.ru

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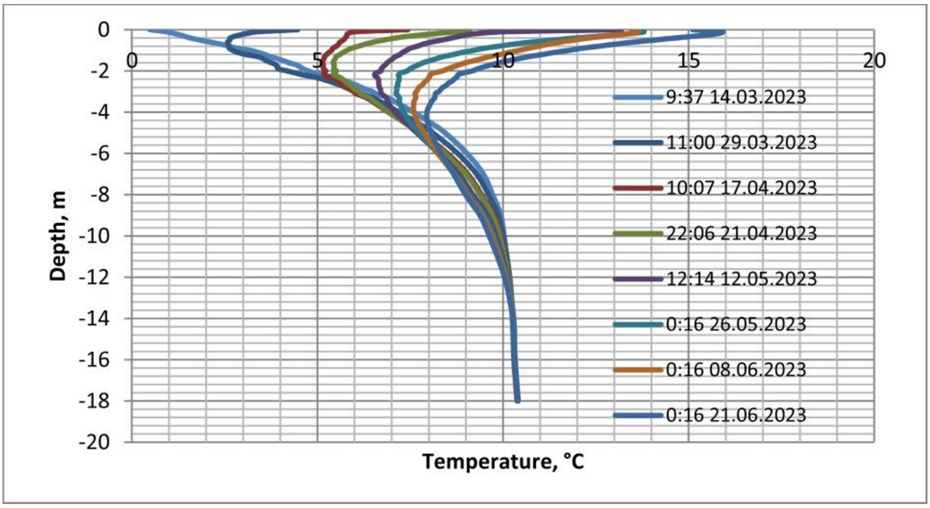
2 Materials and methods

In the light of the tasks set for creating a monitoring system and working out the methodology, a thermal well was drilled and loggers were installed to measure temperature to a depth of 18 meters as part of the creation of a model observation platform at the MSU Meteorological Observatory. At the same time, the average annual air temperature in Moscow is about 10°C. In winter, the ground under the snow cover on the territory of Moscow practically does not freeze.

Also on the northern and southern macroslope of the Anzob Pass (Hissar Ridge, Tajikistan), thermal wells were drilled and loggers were installed to measure temperature to a depth of 3 meters. Aznob Pass (Tajikistan) is located at latitude 39.07 and longitude 68.88 with an altitude of 3373 m above sea level. The average annual temperature there is -2.7°C, but due to heavy snow accumulation, there is no perennial freezing and only seasonal freezing is observed [1-9].

Figure 1 shows the change in temperature in depth (vertically meters, horizontally temperature) at the site of the Moscow State University at the beginning of 2023.

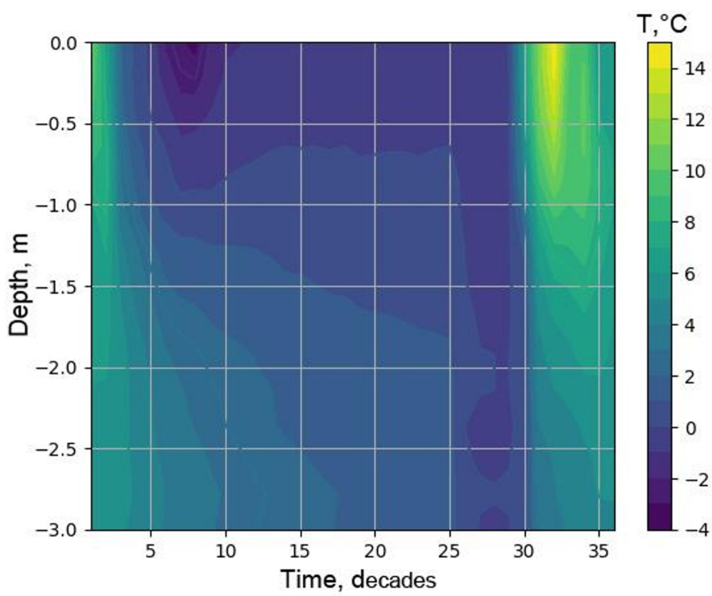
a)



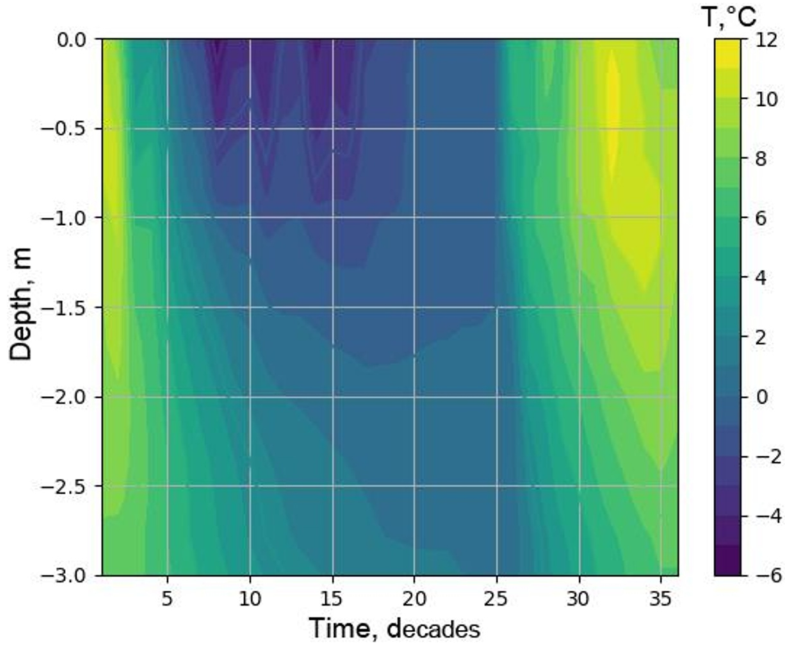
b)

Fig. 1. External view of the well (a) and temperature change in depth (b) (vertically meters, horizontally temperature) at the site of the Moscow State University in early 2023.

Figure 2 shows the change in temperature in depth (vertically, meters) and in time (horizontally, decades) at the Anzob pass (Gissar Range) for the 2019-2020 observation season on the northern and southern macroslope.



a)



b)

Fig. 2. Temperature change in depth (vertically, meters) (a) and in time (horizontally, decades) (b) at the Anzob pass (Hissar Range) for the 2019-2020 observation season on the northern and southern macroslope.

3 Results and discussion

Figure 1 shows the change in temperature in depth (vertically meters, horizontally temperature) at the site of the Moscow State University at the beginning of 2023. It can be seen that the point of zero oscillations is located at a depth of just below 10 m. Next comes the temperature change due to the geothermal flow.

Figure 2 shows the change in temperature in depth (vertically, meters) and in time (horizontally, decades) at the Anzob pass (Hissar Range) for the 2019-2020 observation season for the northern and southern macroslopes based on the results of observations in wells. It can be seen that for the northern macroslope, lower soil temperatures predominate and the period of soil freezing is longer.

According to the data of thermometric observations shown in Figure 2, seasonal freezing of soils in this area on the slopes of the northern exposure is observed from mid-October, and continues until the end of April. At the level of 1.5 m, the temperature of the rocks already at the end of May changes from negative to positive, and by the beginning of June, the rocks are completely thawed.

4 Conclusion

The method of analysis of modern climatic data and observational data presented in the paper made it possible to study the influence of climate on the soil stratum in the area of the seasonally frozen and seasonally thawed layer and to determine the current temperature indicators in the area of rare islands and continuous distribution of permafrost soils. It also

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makes it possible to reveal the features of the development of cryogenic processes controlled by the temperature regime of the upper part of the section of soil strata. The proposed method of temperature monitoring of the soil can be used for geotechnical monitoring of mountain and northern infrastructure in areas of seasonal and long-term freezing in order to protect these infrastructure from destruction due to seasonal and long-term changes in the bearing capacity of the soil.

5 Acknowledgements

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