

SHORT MESSAGES

**About the risks of Arctic infrastructure at permafrost degradation
(Comment on the article)**

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Groups of well-known scientists (Jan Hjort et al.), whose research interests lie in the field of current permafrost changes, have published a research article on risks of permafrost degradation to Arctic infrastructure by the middle of the 21st century. This is an important topic discussed in the world's scientific community, with researchers from different countries warning about the upcoming threats [2, 3, 4, 5]. Such predictions are based on the investigations of global climate change effects on permafrost by T.E. Osterkamp, O.A. Anisimov, and V.E. Romanovsky et al.

A distinctive feature of this study is that it provides risk assessments for almost all types of infrastructure, including cities, roads, railways, airports, oil and gas pipelines, and industrial centers for the year 2050 at the circumpolar scale. The authors set themselves the goal of assessing the potential magnitude of the threat to engineering structures from climate change and permafrost degradation. They estimate that about 70% of current infrastructure is located in areas of unstable permafrost. They warn that by 2050 about three quarters of the population in the Northern Hemisphere permafrost region may be affected by damage to infrastructure associated with permafrost degradation.

Computations presented here are based on the moderate warming scenario (RCP 4.5, global mean air temperature projected to rise by 1.4oC by 2050, with current warming of 1oC). The authors used all available geocryological and climatic databases and took into account ground temperatures, active layer thickness, thawing and freezing indices, precipitation, ground ice content, ground subsidence, etc. The authors did not consider engineering solutions for permafrost preservation such as thermal insulation and thermosyphons in the study. They believe that their results are only indicative in nature and,

therefore, detailed projections and hazard maps should be compiled for individual regions, so that local designers and builders could identify hazard areas when planning future infrastructure in built areas, cities and settlements.

As a permafrost scientist, I believe that this is a relevant article demonstrating the current and future response of infrastructure in permafrost regions. Consequences of climate warming, both current and predicted by this study are quite realistic, as confirmed by research findings for Yakutia. However, such changes are only found in the areas disturbed by human activities or in open, treeless terrain. Observations indicate sinkhole development due to melting of ground ice during the last three decades, which is an early sign of permafrost degradation. High-centered polygons resulting from thermokarst activity, locally called "bylar", have become ubiquitous in forest-free areas. And this fact is obvious for every resident of Yakutia living in the alas regions.

This study will be most useful for our policy-makers, regional and municipal officials planning the strategic development of the Republic of Sakha (Yakutia), which will largely depend on the future state of permafrost. A recommendation by Professor Jan Hjort and his co-authors to conduct local-scale assessments of permafrost-related hazards is highly appropriate in application to the city of Yakutsk. Adaptation to climate and permafrost changes requires rebooting of our thinking, and our future will depend on timely decision making. About 30% of Yakutia is underlain by ice-rich permafrost posing a high risk to infrastructure. On the other hand, the region has enough area suitable for infrastructure development even if the permafrost thaws out completely.

There are other scenarios of future climate development. Along with various estimates of warming trends, there are some scientists who predict climate cooling in the near future. For the permafrost regions, this could be a save option. However, proponents of climate cooling cannot as yet provide any well-grounded evidence.

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