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Permafrost State and Permafrost Dynamics: Key Indicators for Infrastructure Stability

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It's very important to keep the stability of the infrastructure in permafrost zone.


Cooling piles as the protection from permafrost thawing along the railway embankment, Vorkuta Region, 2016


Drainage of the thermokarst lake in Vorkuta vicinity, 2016.

This problem leads to high costs for the regular repair or construction of protective systems, such as cooling pipes.

The infrastructure's stability depends on the state of permafrost and permafrost dynamics.

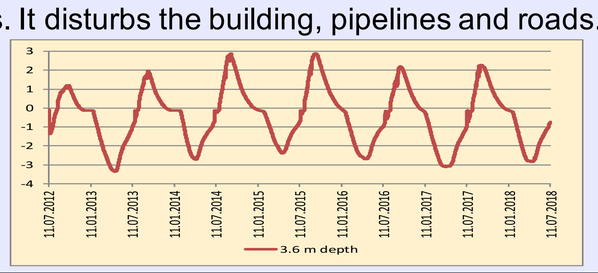
♦ ***State of permafrost*** determines the bearing capacity of the ground. There are some deformed buildings in Vorkuta Region:


Drawdown of embankment, Vorkuta, 2016


Cracking Highway, Transbaikalia, 2017


The thermal erosion gully along the temporal road, Eastern Siberia, photo J. Stanilovskaya, 2010

♦ ***Permafrost dynamics*** affects the activity and types of geocryological processes. It disturbs the building, pipelines and roads.



Periods of temporary warming and cooling lead to the activation of various processes.

Regulatory approaches to the permafrost indicators

A) The state of permafrost is normalized in Russian building Codes.

It is characterized in statics through the average annual temperature of the ground at the depth of penetration of temperature seasonal variations.


СВОД ПРАВИЛ
ОСНОВАНИЯ И ФУНДАМЕНТЫ НА ВЕЧНОМЕРЗЛЫХ ГРУНТАХ
АКТУАЛИЗИРОВАННАЯ РЕДАКЦИЯ
СНиП 2.02.04-88
Soil bases and foundations on permafrost soils
СП 25.13330.2012

Normative indicators are not enough to fully characterize the state of permafrost, because the ground can be saline, gassed and have different heat exchange mechanisms.

<u>Recommended Key Indicators for Infrastructure Stability: the extended list of permafrost state characteristics</u>:

♦ The mean annual integral part of the water content in liquid form (including unfrozen water) in the upper ten-meter layer of ground (by year)

♦ The depth at which seasonal temperature fluctuations do not exceed 0.1° C (by year).

♦ The depth of the permafrost table (by year)

♦ Existing of residual thaw layer (by year)

B). The activity of the processes is normalized in the Russian Codes.

However, it assesses phenomena that are not directly related to the actual process.

The process may die out, and the phenomenon still exists for some time.

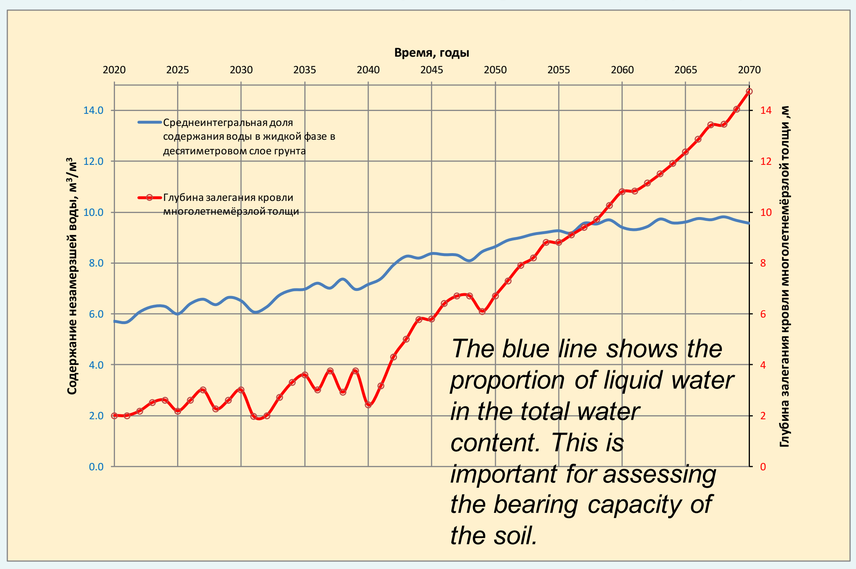

МИНИСТЕРСТВО СТРОИТЕЛЬСТВА И ЖИЛИЩНО-КОММУНАЛЬНОГО ХОЗЯЙСТВА РОССИЙСКОЙ ФЕДЕРАЦИИ
СВОД ПРАВИЛ СП 115.13330.2016
ГЕОФИЗИКА ОПАСНЫХ ПРИРОДНЫХ ВОЗДЕЙСТВИЙ
Актуализированная редакция
СНиП 22-01-95
Издание официальное
Москва 2016
В НАБОР

C) Currently, permafrost dynamics indicators in Russia are not standardized.

There is no generally accepted approach to climate change accounting.

We propose to assess the trends of different periods of change in the recommended key indicators of infrastructure stability.

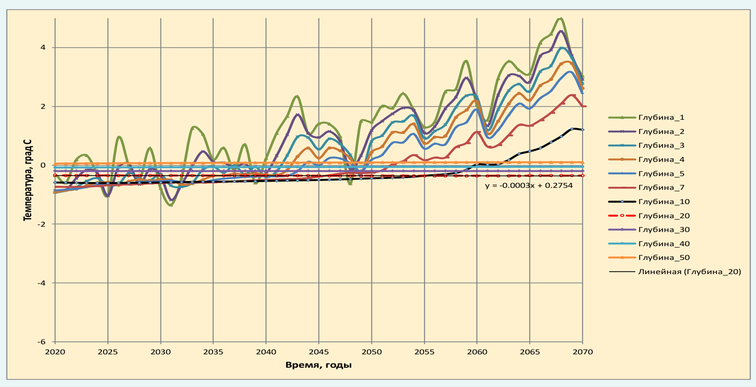
An example of using the mean annual integral part of the water content in liquid form (including unfrozen water) in the upper ten-meter layer of ground (by year)



The blue line shows the proportion of liquid water in the total water content. This is important for assessing the bearing capacity of the soil.

The red line shows the permafrost table position. It's important for designer solution.

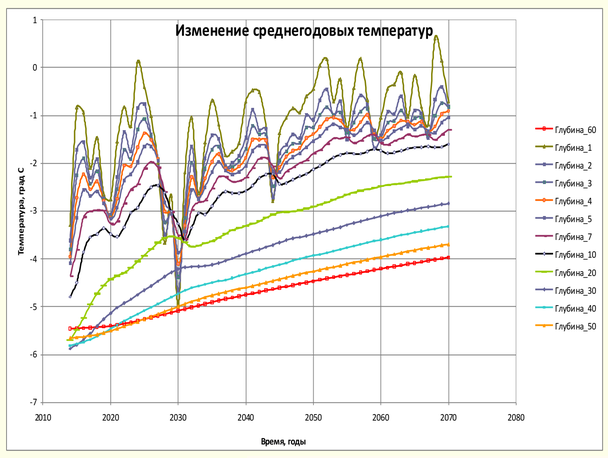
The permafrost forecast for South part of Malozemelskaya Tundra

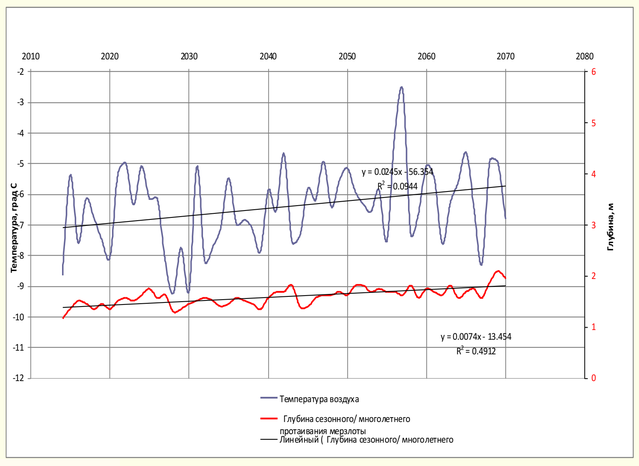


The temperature itself is not sufficient to see important changes in the state of permafrost due to the "zero curtain".

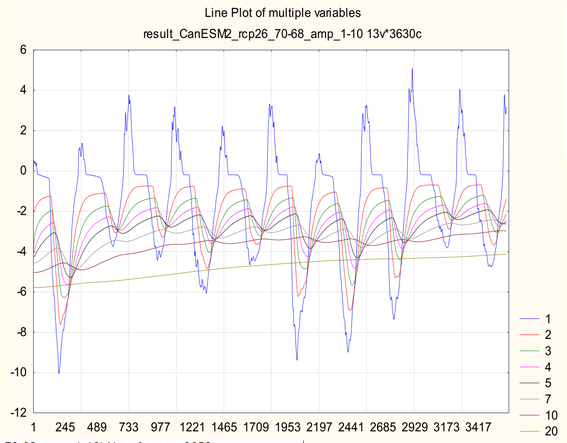
An example of using the depth of seasonal temperature variations as a permafrost status indicator

There is a prediction of the reaction temperature of permafrost and the depth of seasonal thawing, depending on the climate change scenario.





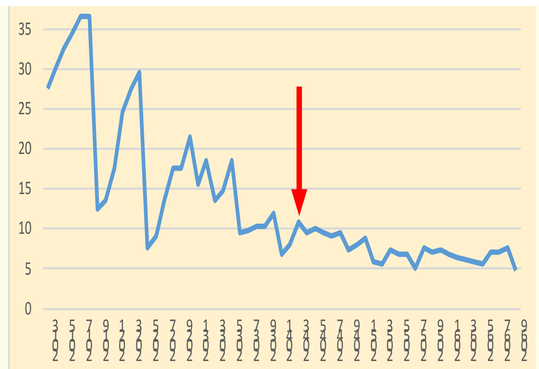
According to spectral analysis data, the theoretical amplitude of seasonal variations at a depth of 10 m does not exceed 0.1 degrees for 2013–2023.



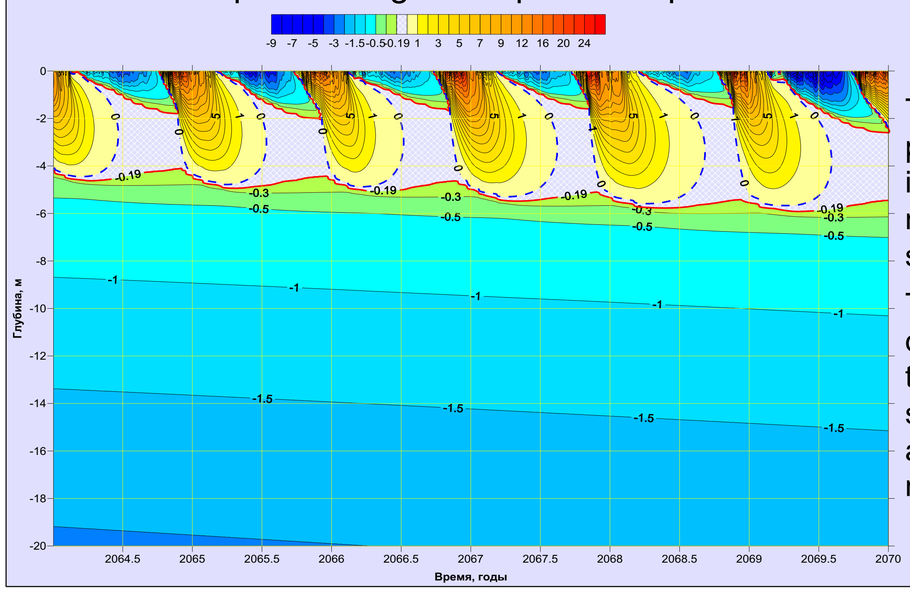
Spectral analysis: 10 (result_CanESM2_rcp26_70-68_amp_1-10) No. of cases: 3650

	Frequency	Period	Cosine Coeffs	Sine Coeffs	Амплитуда
10	0.002740	365.000	-0.039311	-0.083103	0.091932

The actual depth of seasonal fluctuations in ground temperature helps predict the year of a radical reorganization of permafrost state:



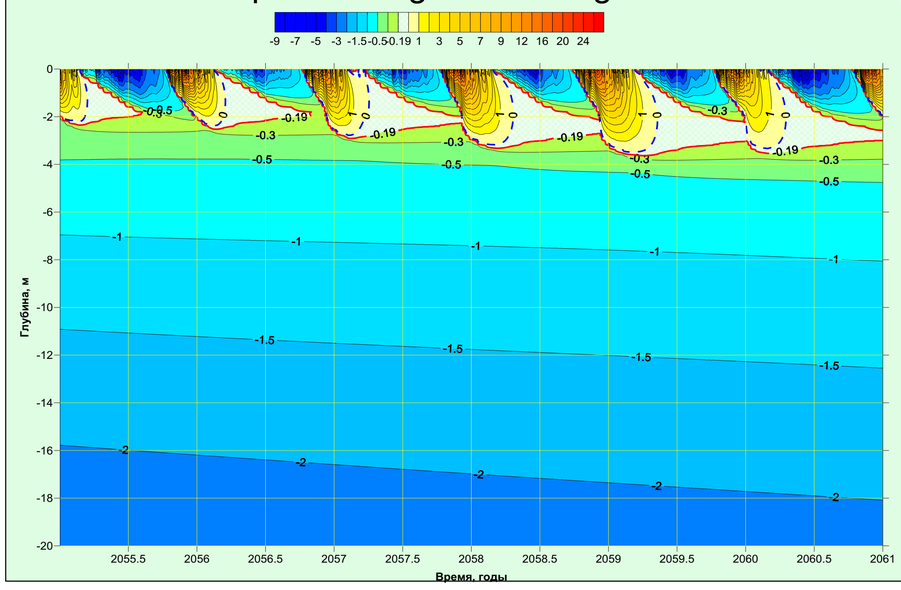
An example of using the depth of the permafrost table (by year)



The depth of the permafrost table provides information about the zone needed for geological survey.

The permafrost degradation rate controls thermokarst activity and should be taken into account in hydrological models.

An example of using the existing of residual thaw layer (by year)



When the depth of permafrost table becomes deeper than the seasonal freezing, the talik dramatically changes the underground water regime.

This event controls the activity of the frost heave.

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