Infrastructure Stability Estimation: Usage of GTN-P Data and Permafrost Forecasting

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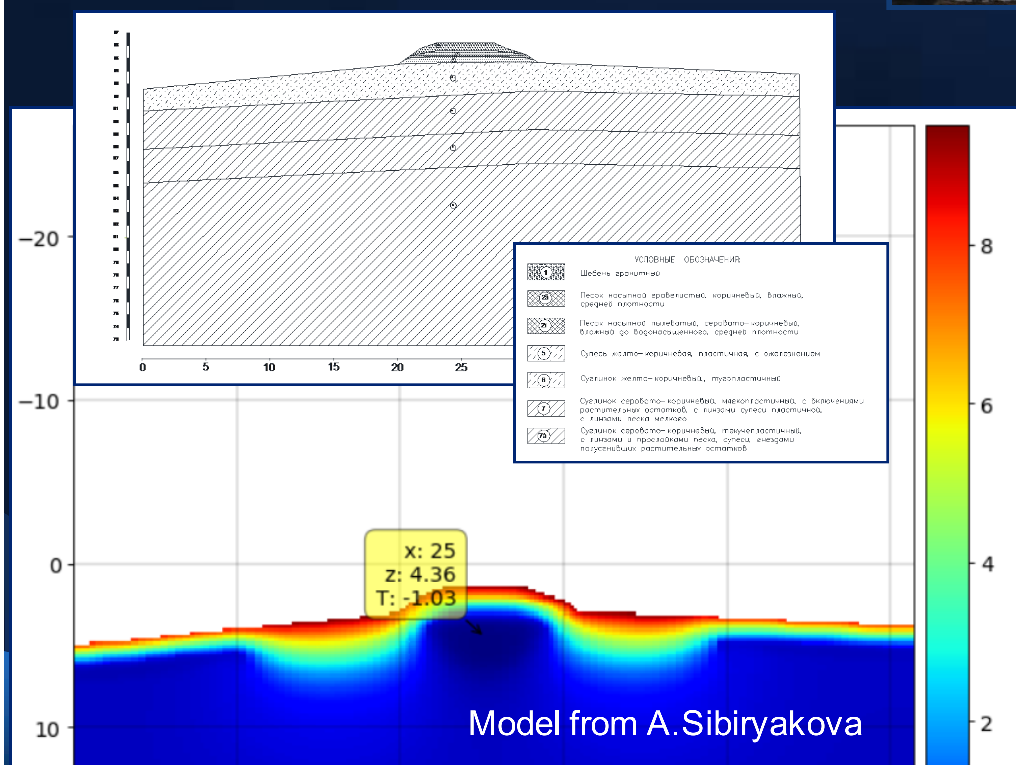
Roads and pipelines transect different permafrost diversity and the various climate zones.

Good example is a railway in the Vorkuta tundra.

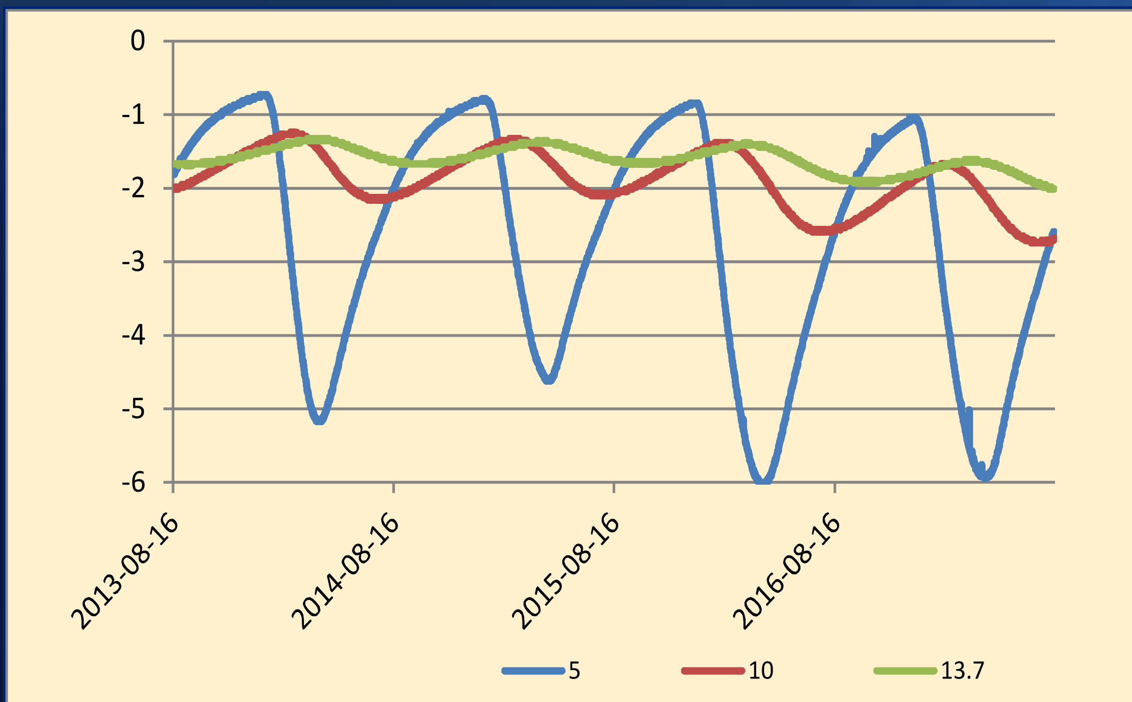
A possible, although time-consuming solution, is to develop **local forecasts** for typical combinations of landscapes and engineering structures.

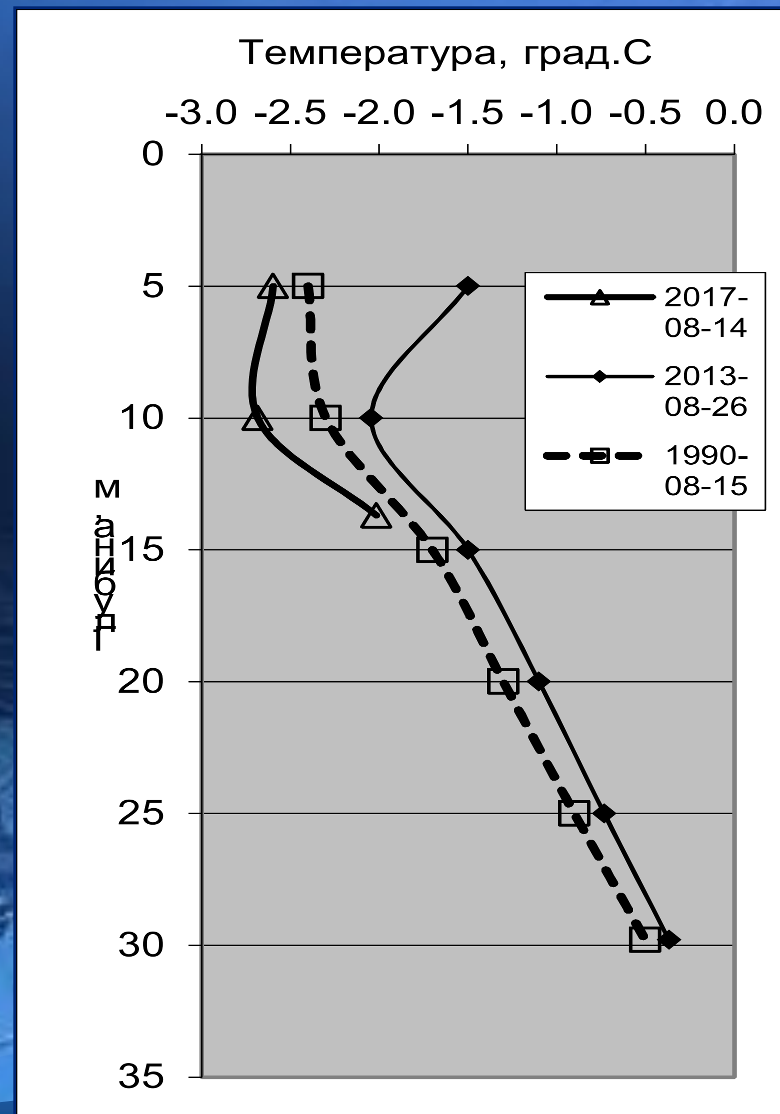
Such forecasts need data about natural permafrost temperature regime that could be use from GTN-P nearest similar landscape.



Model from A.Sibiryakova

Monitoring data provide only a local characteristic of the state and dynamics of permafrost conditions.





This is an example of temporal negative temperature tendency within a long time regional climate warming (Chara Region, Eastern Siberia)

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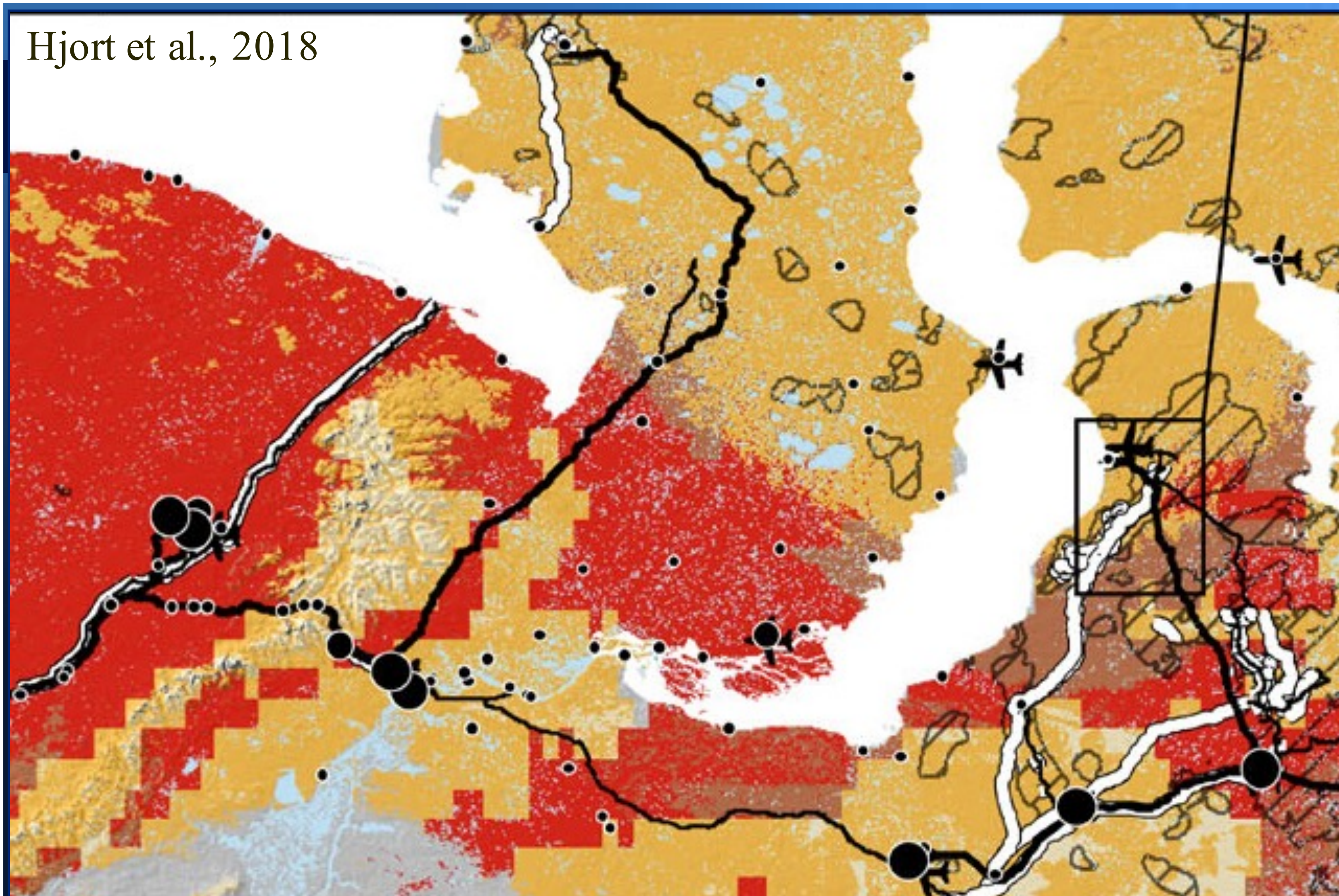
Degrading permafrost puts Arctic infrastructure at risk by mid-century

Jan Hjort[1], Olli Karjalainen[1], Juha Aalto[2,3], Sebastian Westermann[4], Vladimir E. Romanovsky[5,6], Frederick E. Nelson[7,8], Bernd Etzelmüller[4] & Miska Luoto[2]

Degradation of near-surface permafrost can pose a serious threat to the utilization of natural resources, and to the sustainable development of Arctic communities. Here we identify at unprecedentedly high spatial resolution infrastructure hazard areas in the Northern Hemisphere's permafrost regions under projected climatic changes and quantify fundamental engineering structures at risk by 2050. We show that nearly four million people and 70% of current infrastructure in the permafrost domain are in areas with high potential for thaw of near-surface permafrost. Our results demonstrate that one-third of pan-Arctic infrastructure and 45% of the hydrocarbon extraction fields in the Russian Arctic are in regions where thaw-related ground instability can cause severe damage to the built environment. Alarmingly, these figures are not reduced substantially even if the climate change targets of the Paris Agreement are reached.

Sometimes it is necessary to perform infrastructure stability estimation for regions and to compare regional assessments.

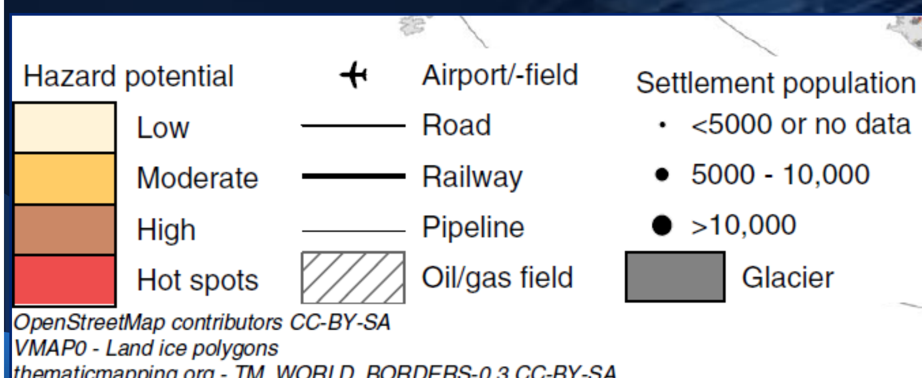
Good example implementation in the article



Regional estimates are based on complex algorithms.

They **require a variety of input data.**

The accuracy and reliability of such data is different.



Regional and local estimations of infrastructure stability are founded **on permafrost state and dynamics characteristics.**

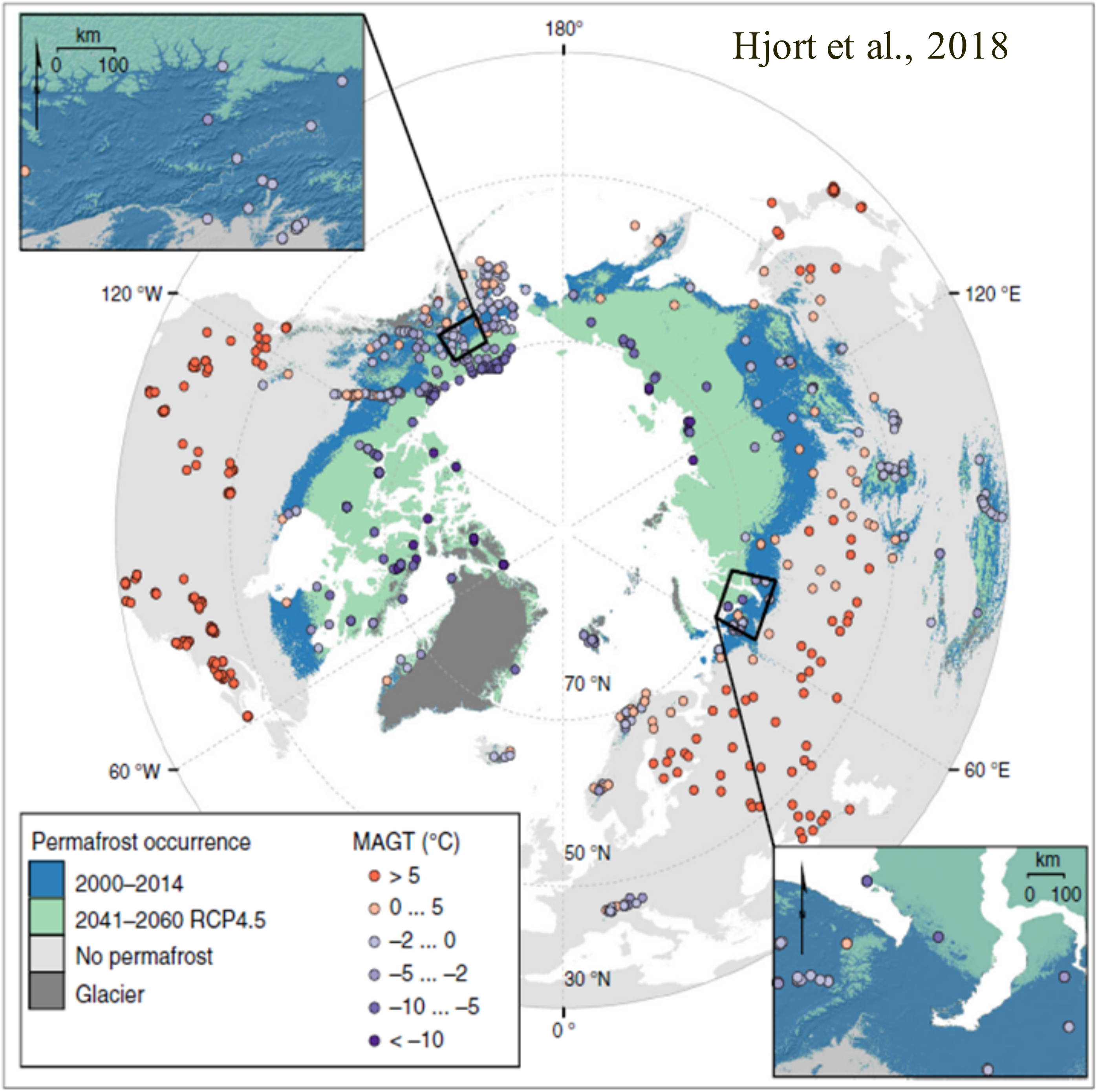
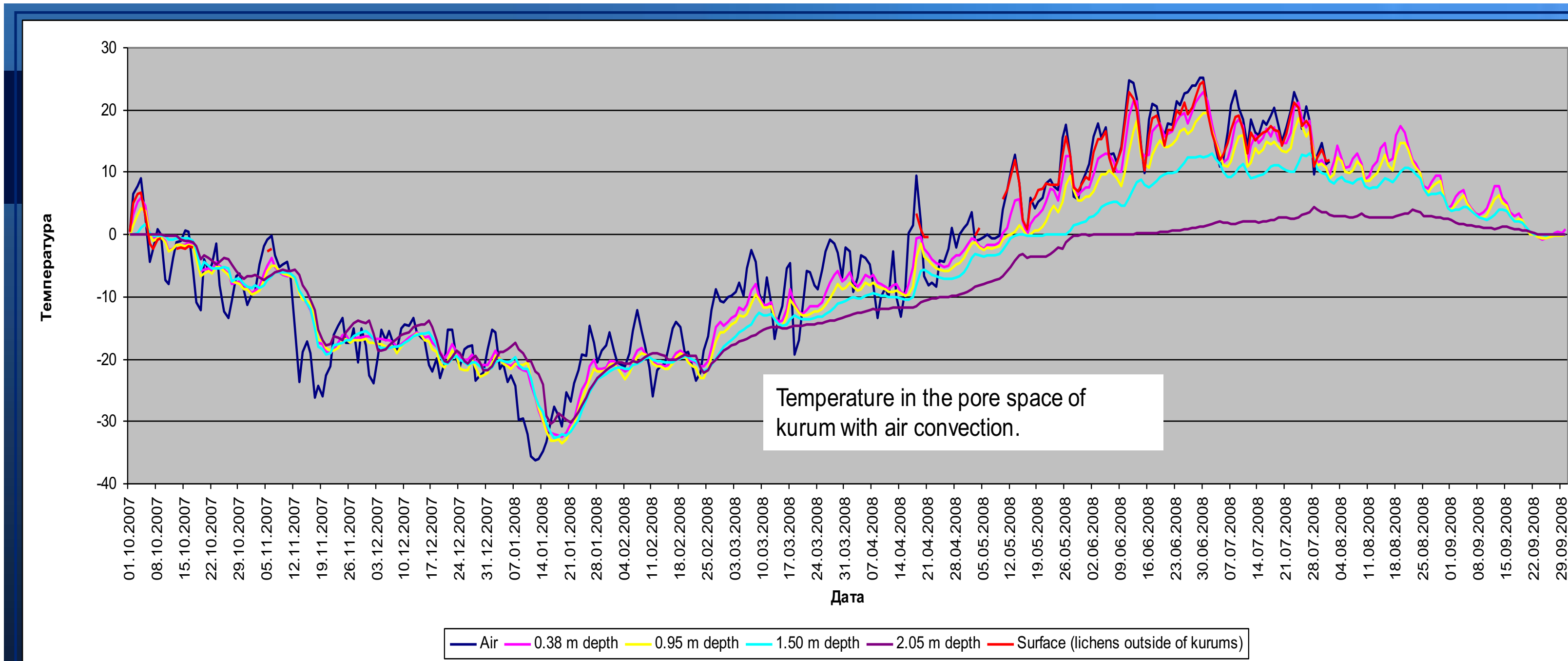


Fig. 1 Distribution of permafrost in the baseline (2000-2014) and future (Representative Concentration Pathway 4.5 2041-2060) climates[23]. Note that the baseline extent of permafrost (blue) includes future distribution (greenish). The location and observed mean annual ground temperature (MAGT) of the data points (boreholes) are shown with coloured circles

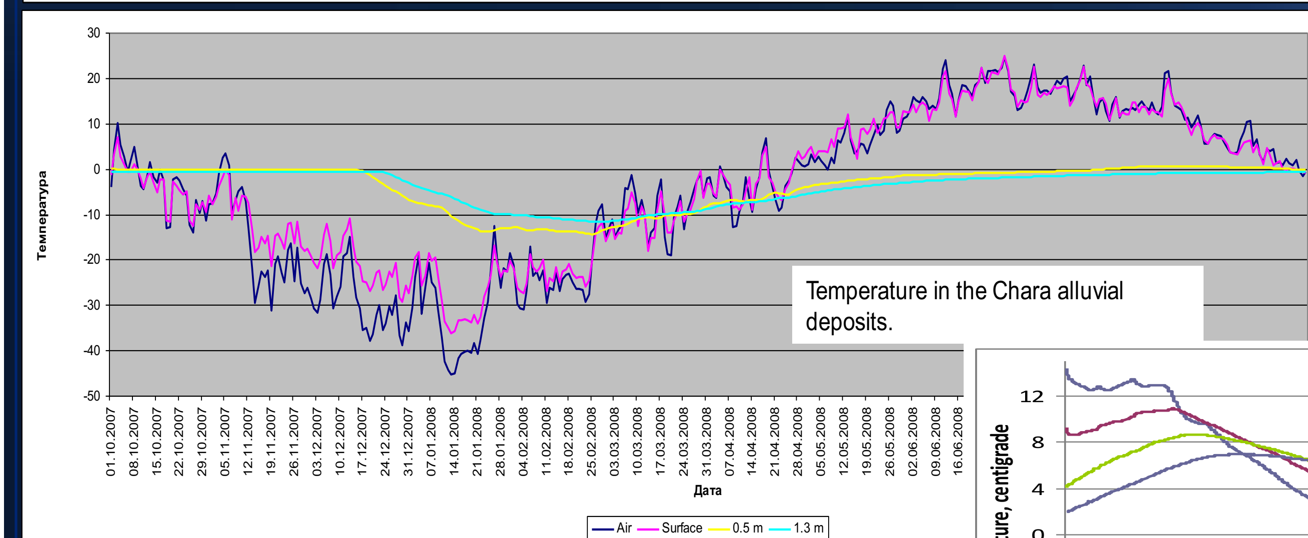
One of the indicators of the state and dynamics of permafrost is **mean annual ground temperature.**

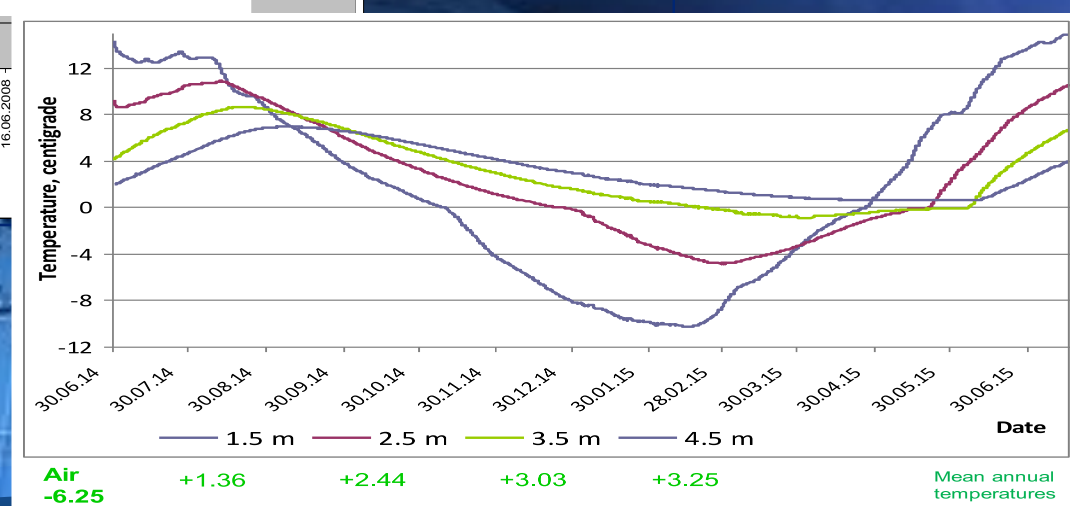
GTN-P data is used here.

The question is **how comparable this data** is to each other.



This is an example of the differences in the characteristic features of the temperature regime in similar microclimatic conditions (Chara region, Eastern Siberia)





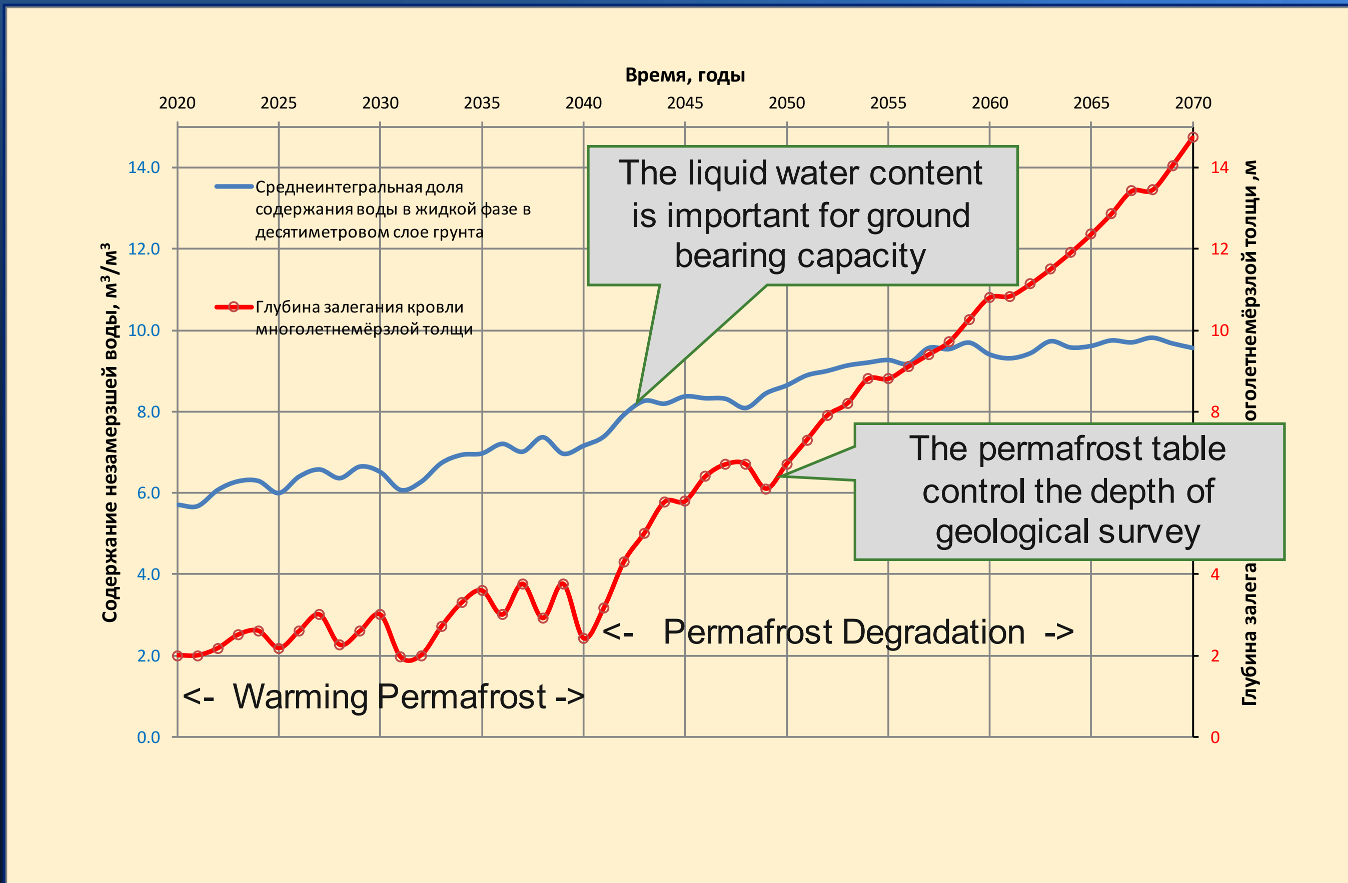
The observed difference is due to inequality in the nature of heat transfer, which can be conducted by air convective and water convective.

Ground temperature and active layer depth indicators from GTN-P are not enough to fully characterize the state of permafrost, because ground can be saline, gassed and has different heat exchange mechanisms.

Recommended Key Indicators for estimation of Infrastructure Stability form the extended list of permafrost state characteristics:

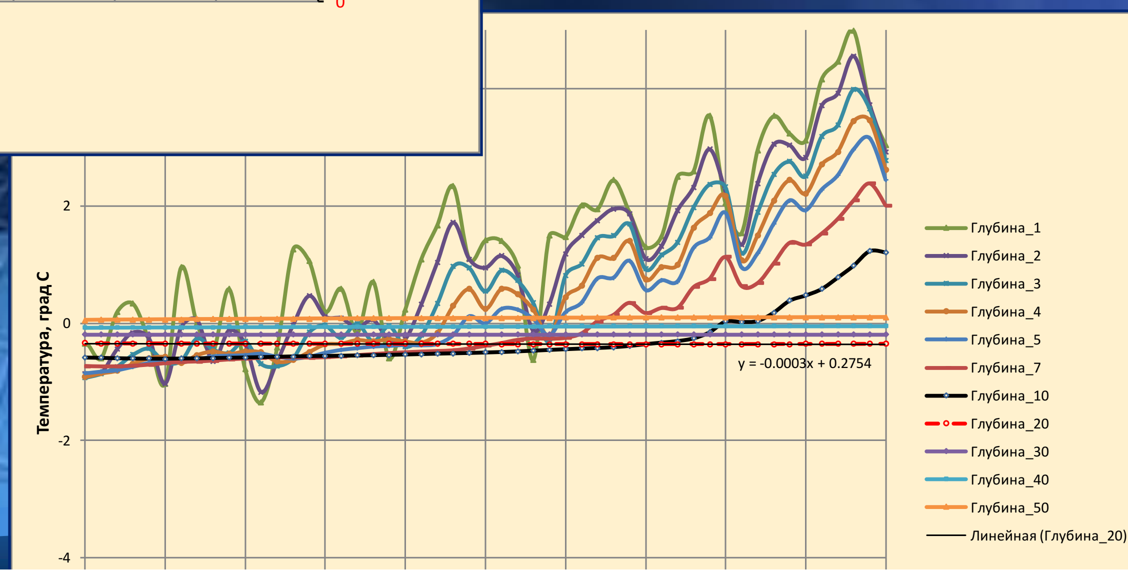
♦ **The mean annual integral part of the water content in liquid form (including unfrozen water) in the upper ten-meter layer of ground (by year)**	*Can be obtained from the temperature data GTN-P with the addition of unfrozen water characteristics and data about ground salinity.*
♦ **The depth at which seasonal temperature fluctuations do not exceed 0.1° C (by year)**	*Can be obtained from GTN-P temperature data (deep borehole are important)*
♦ **The depth of the permafrost table (by year)**	*Can be obtained from GTN-P temperature and active layer data with adding the modeling or geophysical survey*
♦ **Existing of residual thaw layer (by year)**	*Can be obtained from GTN-P active layer data with adding the modeling*

Values of Key Indicators of permafrost state form the trend, that describe the dynamics of permafrost conditions



The permafrost forecast for South part of Malozemelskaya Tundra

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)



Method of model data adding to GTN-P monitoring rows

♦ If the data series are short or incomplete, then it is necessary to develop a local numerical model of the temperature regime taking into account the ground salinity, the initial temperature distribution and the heat fluxes from bottom.

♦ Such a model should be calibrated and validated according to GTN-P data.

♦ The values of permafrost state and dynamics indicators should be obtained from modeling series.

The point of the GTN-P data:

- wide territorial coverage;
- a variety of observed landscapes, active layer and depths of observation;
- repeatability of observations at each point;
- the presence of landscape characteristics, description of disturbances;
- the existence of a metadata base and the availability of data in digital form.

We recommend to using the GTN-P data for:

♦ Local modeling of permafrost ground as a source of data on background conditions (initial not-disturbed temperature distribution, tendency of mean annual temperature change within the climate change).

♦ Local permafrost modeling as the source of model validation data.

♦ Source of data about the limits of regional variability of permafrost condition.

We do not recommend using GTN-P data for :

- ♦ Statistical regional aggregation of permafrost data.

- ♦ Regional permafrost modeling as a source of input data for validation (such methods of climate re-analysis).


Thank You !