Thermocirques and their activity factors in the central part of Yamal Peninsula

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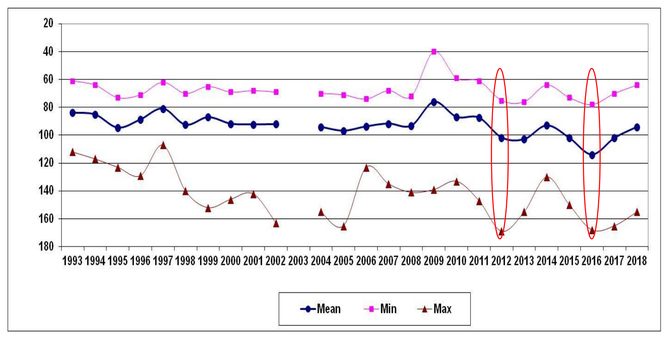
About 90 new thermodenudation features, most being relatively small retrogressive thaw slumps, and at least 20 of those big thermocirques were observed in 2013 in the central part of Yamal Peninsula within the area of 350 sq.km. Thermodenudation features appeared or re-activated in 2012-2013 after extremely warm summer, and actively grow in size since then. While ground ice close to the surface is a prerequisite for thermocirque formation, the process is triggered by warming trend and deepening of the active layer. Expansion of this landform depends on the volume of ice and further warming (*Leibman et al., 2008*; ***Khomutov et al., 2018*). Stabilization of this landform is usually caused by either exhaustion of the ice body, or by insulating of the exposed ice by active accumulation of flowing material (*Leibman et al., 2008*; *French, 2017*). The last is resulting from active thaw on the one hand and dry summer weather on the other hand. Observations in Canada show that thermocirques become stabilized within 30–50 summers after their initiation (*French, 2017*) while near the Kara sea coast it took about 12 years (*Leibman et al., 2008*).**

According to our direct observations thermocirques activated in 2012 triggered by extremely warm summer of 2012, and expanded at a various rate. Six thermocirques from 1 to 25 thousand sq.m of initial area annually monitored (*Khomutov et al., 2017*) give approximation of the expansion rates. The annual rates of thermocirque area enlargement for 7 years of monitoring since 2012 vary from 1 to 6 thousand sq.m (4 to 98% of annual growth, *Khomutov et al., 2018*), and depend in part on climatic features of each year. Those kept stable after 2012, activated or re-activated in even warmer 2016.

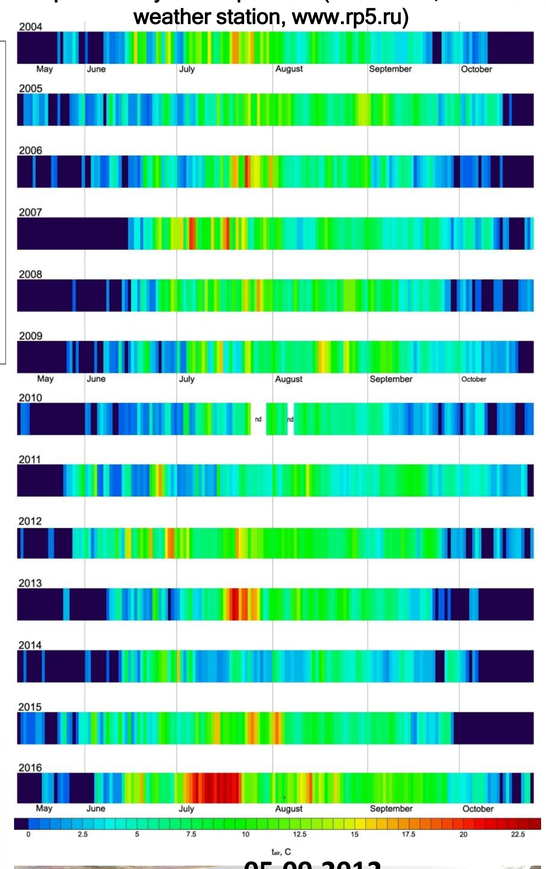
Location

Climatic factors of cryogenic landsliding activation

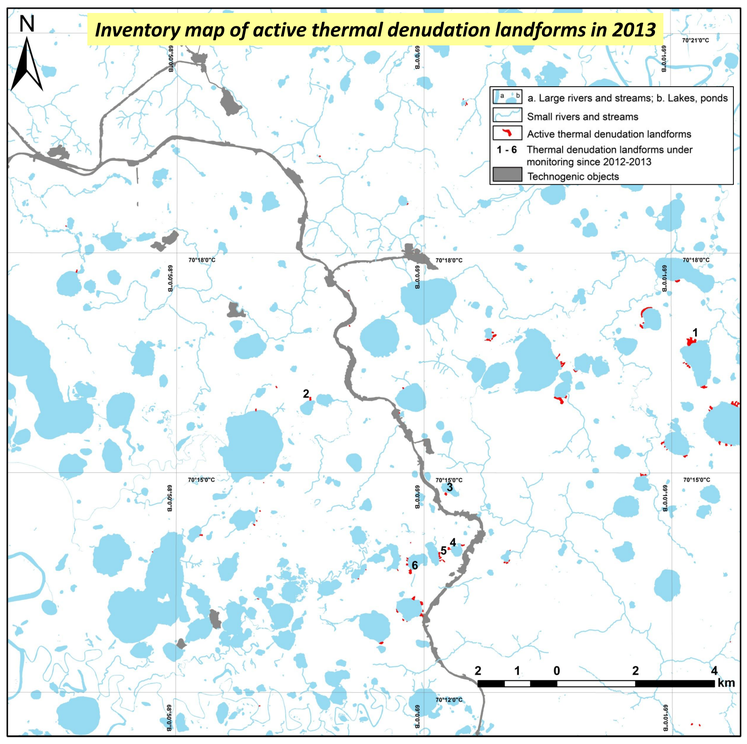
Summary of active-layer depth measurements at the CALM grid (1993-2018)



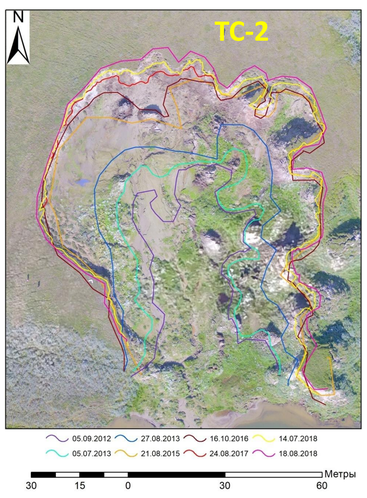
Warm period daily air temperature (2004-2016, Marre-Sale weather station, www.rp5.ru)

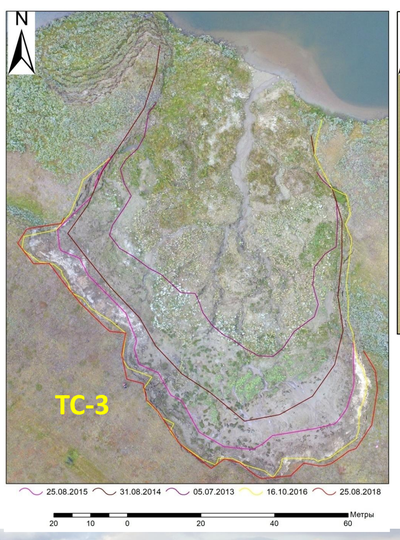


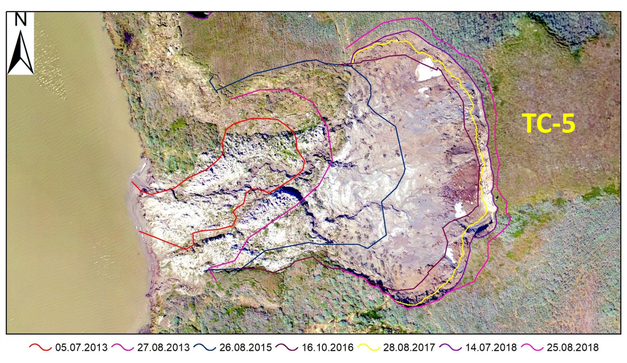
Inventory map of active thermal denudation landforms in 2013

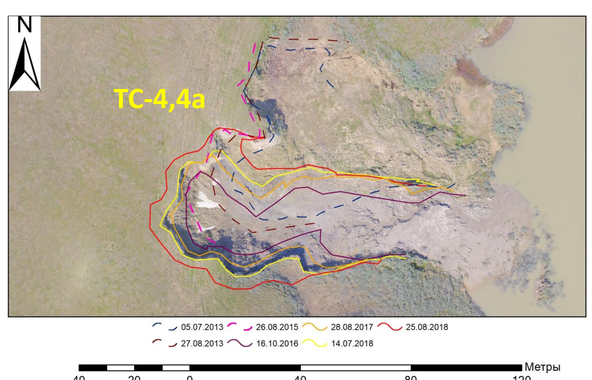


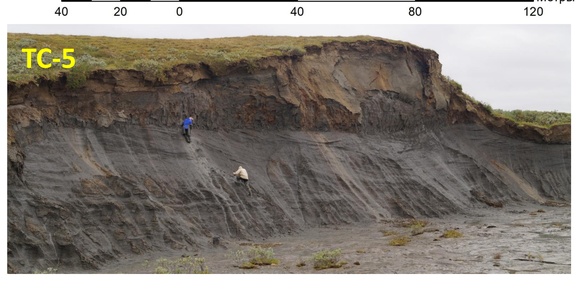
Monitoring of key thermocurques

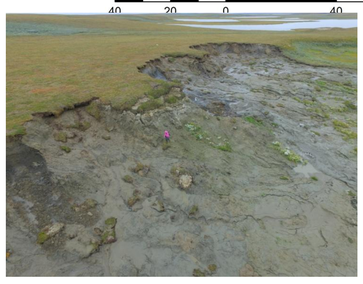


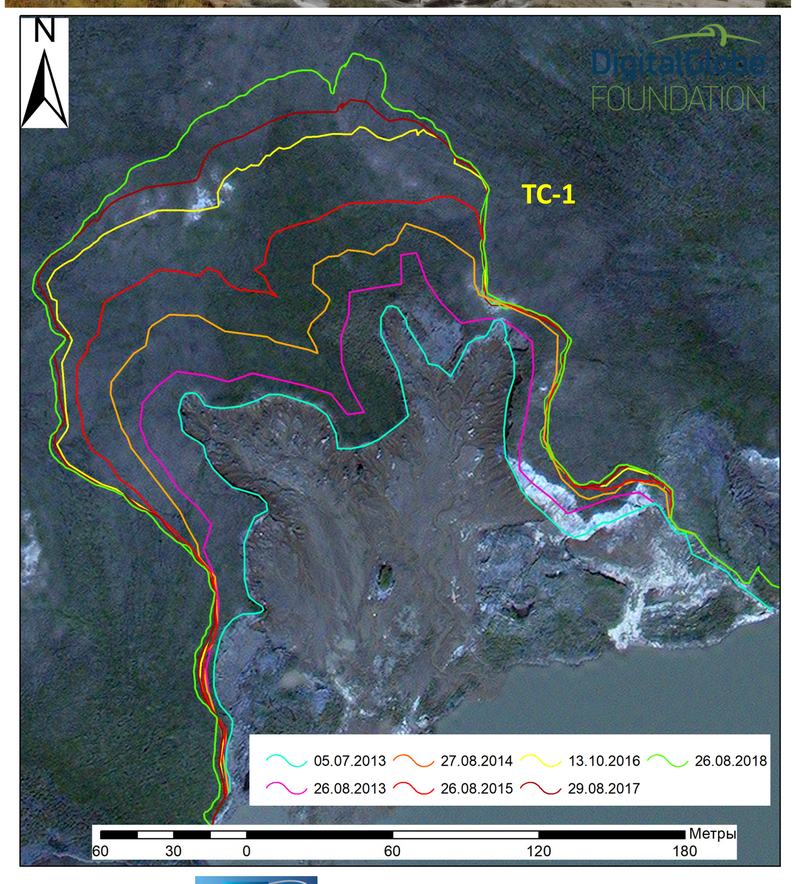


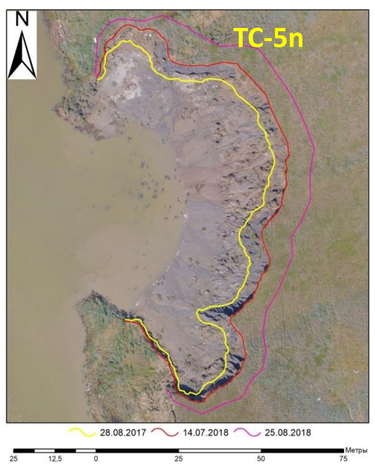


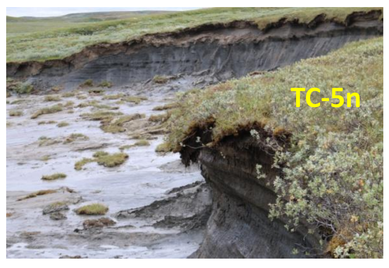


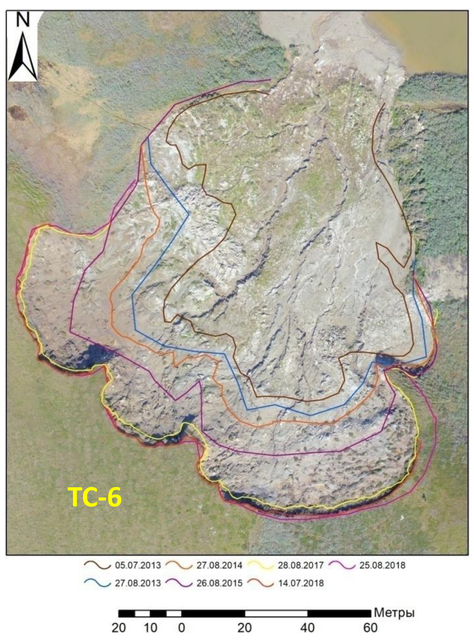




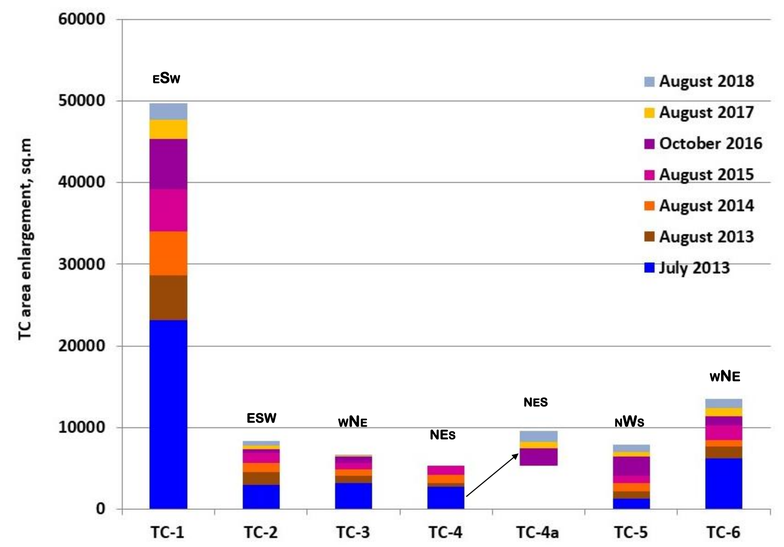








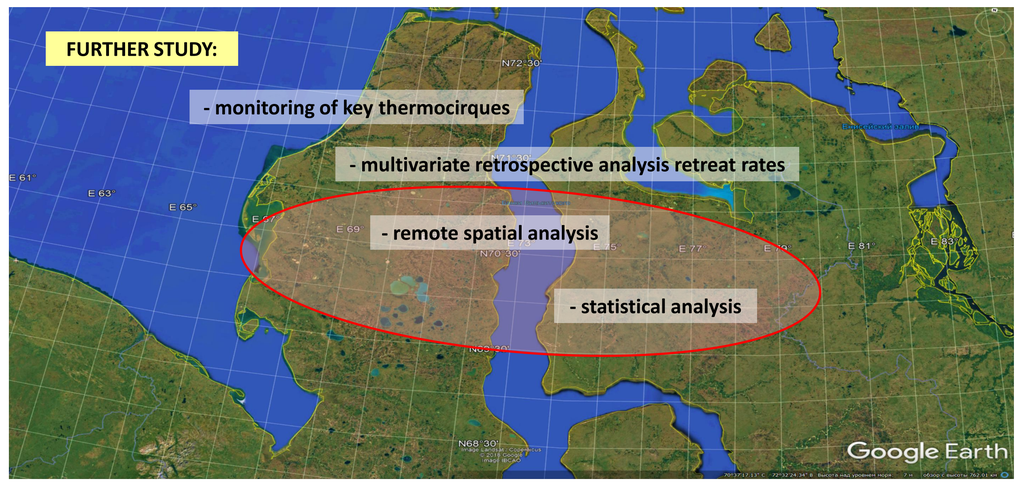
Thermocirque area enlargement



Vehicle tracks observed over some thermocirques, most likely appeared before the main event of thermocirque activation in 2012, so the role of man-made disturbances is not crucial in activating the process, but this impact could have played a role in re-activation in 2016 though the tracks look already overgrown by pioneer vegetation. Active layer depth at such disturbances is up to 30% deeper than in the natural conditions (*Khomutov, Khitun, 2014*).

Other controls of thermocirque growth are: slope aspect (southern-facing slopes are retreating faster), size and position of tabular ground ice in the section (the thicker is the layer and the closer to the surface, the faster growth rate).

While the coastal thermocirques grow under the additional action of the waves, inland thermocirques may rely only on the warming trend and amount of available water to help sediment flow away from thermocirque bottom. If the summer temperature rise is not accompanied by significant atmospheric precipitation, then sediment yield and removal are slowed down by landslide bodies in the transition zone. In this case thermocirque may stabilize in a short time and re-activate due to occasional exposure of tabular ground ice at the next extreme air temperature event and possible man-made effect as was observed in summer 2016 when stabilized thermocirque reactivated (*Khomutov et al., 2017*).



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References ***& related publications:***

French, H. M., 2017. The Periglacial Environment. Fourth Edition. Hoboken, NJ : JohnWiley & Sons, 544 pp.

Khomutov A., Leibman M., Dvornikov Yu., Gubarkov A., Mullanurov D., Khairullin R. 2017. Activation of Cryogenic Earth Flows and Formation of Thermocirques on Central Yamal as a Result of Climate Fluctuations // Advancing Culture of Living with Landslides. Proceedings of World Landslide Forum 4, May 29 – June 2, 2017, Ljubljana, Slovenia, Eds.: K.Mikoš, V.Vilímek, Y.Yin, K.Sassa, Vol.5, Landslides in Different Environments. Springer International Publishing AG. P. 209-216.

Khomutov A.V. Dvornikov Yu.A., Kizyakov A.I., Leibman M.O., Babkina E.A., Babkin E.M., Mullanurov D.R., Khairullin R.R. 2018. Monitoring of thermal denudation relief forms and gas-emission craters on Central Yamal. Proceedings of the extended meeting of the Scientific Council on Earth Cryology RAS "Actual problems of geocryology" on May 15-16, 2018, vol.1. Moscow, University Book publisher, pp. 206–213 (In Russian).

Khomutov A.V., Khitun O.V. 2014. Dynamics of vegetation cover and active layer depth in the typical tundra of Central Yamal under technigenic impact. Tyumen State University Herald, Earth Sciences, 4: 17–27 (In Russian).

Leibman M.O., Gubarkov A.A., Khomutov A.V., Kizyakov A.I., Vanshtein B.G. Coastal processes at the tabular-ground-ice-bearing area, Yugorsky Peninsula, Russia // Proc. of the 9th International Conference on Permafrost, 29 June – 3 July 2008, University of Alaska Fairbanks, USA, 2008, Vol.1, P.1037–1042