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Significant melting of ice-wedges and formation of thermocirques on hill-slopes of thermokarst lakes in Central Yakutia (Siberia)

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On Earth, permafrost containing a high ice volume (referred as ice-rich) are sensible to climate change, they have been regionally degraded (thermokarst) during the early Holocene climatic optimum forming numerous thermokarst lakes in Central Yakutia (eastern Siberia). Recent temperature increases in the Arctic and Subarctic have been significantly greater than global averages. The frequency and magnitude of terrain disturbances associated with thawing permafrost are increasing in these regions and are thought to intensify in the future. Therefore, understand how is the current development of thermokarst is a critical question.

Here, we describe the significant melting of ice-wedges on slopes of thermokarst lakes that leads to formation of amphitheatrical hollows referred as thermocirques. The evolution of thermocirques in Central Yakutia has been little studied and analyzing their formation could help to understand the recent thermokarst in relation to climate change in Central Yakutia. We studied the thermocirques at two scales: (i) field surveys of different thermocirques in July 2009-2010 and October 2012 to examine the processes and origin of melting of ice-wedges and; (ii) photo-interpretation of time series of satellite images (KH-9 Hexagon images of 6-9 m/pixel and GeoEye images of 50 cm/pixel) to study the temporal evolution of thermocirques.

The melting of ground-ice on the scarp of thermocirque triggers falls and small mud-flows that induce the retreat of the scarp parallel to itself. Based on field studies and on GeoEye image comparison, we show that their rate of retrogressive growth is 1-2 m/year. On the hill-slopes of lakes, the thermokarst could be initiated by different processes that lead to the uncover and then melting of ice-wedges: thermal erosion by the waves of the ice-rich bluff; active-layer detachment (a form of slope failure linked to detachment of the seasonally thawed upper ground); flowing of water on the slope (precipitation) or; increase of near-surface temperature (insolation, summer temperature). We suggest that the preferential occurrence of thermocirques on south-facing slopes of lakes could emphasize the role of insolation as a factor controlling the preferential melting of ice-wedges.

The air temperatures are shown to have increased in Central Yakutia over years and deciphering if ongoing climate warming could lead to an increased development of thermocirques along lake slopes in Central Yakutia is a question that we will address in future study.