Massive thermokarst lake area loss in continuous ice-rich permafrost of the northern Seward Peninsula, Northwestern Alaska, 1949-2015

Guido Grosse[1], Benjamin M. Jones[2], Ingmar Nitze[1], Prajna R. Lindgren[3], Katey M. Walter Anthony[4], & Vladimir E. Romanovsky[3]

[1] *Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Germany*
[2] *Alaska Science Center, US Geological Survey, Anchorage, AK, USA*
[3] *Geophysical Institute, University of Alaska Fairbanks, USA*
[4] *Water and Environmental Research Center, University of Alaska Fairbanks, USA*

Thermokarst lakes are important factors for permafrost landscape dynamics and carbon cycling. Thermokarst lake cover is especially high in Arctic lowlands with ice-rich permafrost. In most of these regions, multiple lake generations have been identified that overlap each other in space and time, giving rise to the hypothesis of thermokarst lake cycling and its association with complex cryostratigraphical conditions where multiple lacustrine and palustrine sequences may follow on top of each other and talik and carbon cycle histories are complicated. In northwestern Alaska on the northern Seward Peninsula, ice-rich permafrost lowlands have strongly been affected by thermokarst during the Holocene and up to six generations of lake basins overlap spatially (Jones et al., 2012). Modern thermokarst lakes are also abundant in this region and expand gradually by thermo-erosion along shores (Jones et al., 2011).

We here report on the analysis of multi-temporal remote sensing data for a 12,200 km^2 lowland area in the relatively warm continuous permafrost zone of the northern Seward Peninsula, demonstrating that thermokarst lake drainage in this region was occurring on a massive scale from 1949-2015. Contrary to most previous studies that suggest an increase in thermokarst lake area in continuous permafrost, we observed a significant net decrease in thermokarst lake area largely due to catastrophic lake drainage. Lateral lake expansion by thermo-erosion continued but did not offset the net area loss. Climate data analysis revealed a potential correlation with increased winter precipitation that may have resulted in a combination of high lake water levels, increased spring runoff with higher potential for drainage channel formation, and near-surface permafrost degradation, ultimately enhancing lake drainage. The observed magnitude of lake drainage implicates strong and lasting impacts on regional hydrology, biogeochemical cycling, surface energy budgets, state of the permafrost, ecosystem character, waterfowl and fish habitats, and subsistence lifestyles in the study region, portions of which belong to the Bering Land Bridge National Preserve. The datasets used in this analysis include a wide range of remote sensing images and topographic data available for this region, such as aerial photography, historic topographic maps, high resolution satellite images (Corona, Spot, Ikonos, Quickbird, Worldview, GeoEye), and the full Landsat archive. Field studies included reconnaissance flights targeting freshly drained lakes and ground based data collection such as lake basin coring.

Our findings suggest that a significant portion of lakes in this region has drained over the last decades and that in particular large lakes are vulnerable to disappearance. Initial analyses of relationships of lake drainages with permafrost distribution in the region suggest positive correlations between lake loss and permafrost degradation in much of the region. Our findings highlight that permafrost and lake-rich landscapes in Alaska are already changing rapidly and permanently in a warming world.

This set of studies was supported by funding from NASA Carbon Cycle Sciences, NSF Arctic System Sciences, the European Research Council, and the Western Alaska Landscape Conservation Cooperative.

Jones B, Grosse G, Arp CD, Jones MC, Walter Anthony KM, Romanovsky VE (2011): Modern thermokarst lake dynamics in the continuous permafrost zone, northern Seward Peninsula, Alaska. Journal of Geophysical Research – Biogeosciences, 116, G00M03.

Jones MC, Grosse G, Jones BM, Walter Anthony KM (2012): Peat accumulation in a thermokarst-affected landscape in continuous ice-rich permafrost, Seward Peninsula, Alaska. Journal of Geophysical Research – Biogeosciences, 117, G00M07.