Pan-arctic trends in lake and wetland thermokarst: Implications for carbon storage and methane fluxes

MERRITT R. TURETSKY[1*], DAVID OLEFELDT[2] AND A. DAVID MCGUIRE[3]

[1*]Department of Integrative Biology, University of Guelph
[2]Department of Renewable Resources, Univerity of Alberta
[3]U.S. Geological Survey, University of Alaska Fairbanks

Carbon release from permafrost thaw and the microbial decomposition of previously frozen organic matter is considered one of the most likely positive feedbacks from terrestrial ecosystems to the climate system in a warmer world. Permafrost thaw can involve the gradual deepening of the seasonally thawed layer, but in certain landscape types also can occur via abrupt thermokarst development through the thaw of ground ice and subsequent subsidence that potentially affects the entire soil profile. Thermokarst leads to the formation of collapse scar wetlands as well as the evolution of thaw lake initiation, expansion, and drainage. We are using pan-arctic mapping of spatial data known to predispose landscapes to thermokarst along with land cover change studies to better understand the relevance of abrupt thaw to the overall permafrost C feedback. We estimate that thermokarst terrains cover 3.6 x 10^6 km^2, or 20% of the northern permafrost domain. However, given disproportionally high soil organic carbon content, thermokarst terrains are estimated to store ~30% of the total soil organic carbon stored in the upper 3 meters of soil in the permafrost domain, and likely an even larger fraction when deeper carbon stocks are considered.

Some of the highest CH_4 emissions in the Arctic have been observed in thermokarst wetlands and thaw lakes. At the Alaska Peatland Experiment (APEX) sites, a significant fraction of CH_4 is released from thermokarst wetlands via ebullition or bubbling. Our results indicate that bubbles are mostly located in surface peat and contain modern C. Rates of CH_4 release through ebullition increase with the abundance of sedges, which dominate young thermokarst landforms. These and other empirical studies show that abrupt thaw can influence C emissions by stimulating the mineralization of previously thawed permafrost C at depth, but also influence emissions of more recently fixed C through land cover and aquatic vegetation change. We will report on our approach in using these process-level studies to parameterize a book-keeping model to track the effects of thermokarst disturbance on CO_2 and CH_4 emissions at pan-arctic scales.