Present-day permafrost carbon feedback from thermokarst lakes

Katey Walter Anthony[1], Ronald Daanen[2], Peter Anthony[1], Thomas Schneider von Deimling[3], Chien-Lu Ping[1], Jeffrey Chanton[4], & Guido Grosse[3]

[1] *University of Alaska Fairbanks*; [2] *Alaska Department of Natural Resources*
[3] *Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research*; [4] *Florida State University*

Rapid temperature rise during recent decades (IPCC 2013) is causing permafrost in the Arctic to warm and thaw. This thaw exposes previously frozen soil organic carbon (SOC) to microbial decomposition, generating greenhouse gases methane (CH_4) and carbon dioxide (CO_2) in a feedback process that leads to further warming and thaw. A growing number of studies model the future permafrost carbon feedback (PCF) to climate warming [Koven et al., 2015, Schneider von Deimling et al., 2015]. However, despite observations of widespread permafrost thaw during recent decades and forecasts of thaw during the next 25-100 years [Koven et al., 2015], no research has quantified the PCF for recent decades. This is in part due to the difficulty of detecting the net movement of old carbon from permafrost to the atmosphere over years and decades amidst large input and output fluxes from ecosystem carbon exchange. In contrast to terrestrial environments, thermokarst lakes provide a direct conduit for processing and emission of old permafrost carbon to the atmosphere, and these emissions are more readily detectable. Results here are based on Walter Anthony et al. [submitted], whereby we quantified the permafrost SOC input to a variety of thermokarst and glacial lakes in Alaska and Siberia in thermokarst zones, defined as areas where land surfaces have transitioned to open lakes due to permafrost thaw during the past 60 years, the historical period most commonly covered by remote-sensing data sets. We also quantified the resulting methane emitted from these active thermokarst lake zones. Using field work, numerical modeling of thaw bulbs, remote sensing and spatial data analysis we will report on the relationship between methane emissions from thermokarst zones and SOC inputs to lakes across gradients of permafrost and climate in Alaska. We will also define the relationship between radiocarbon ages of methane and permafrost soil carbon entering into lakes upon thaw. We will report on the present-day PCF relationship between thaw of permafrost SOC and resulting greenhouse gas release.

An extrapolation of our results to the panarctic permafrost region will be presented and compared to permafrost carbon mass balance approaches. The fraction of the terrestrial permafrost carbon pool that has been released as methane from thermokarst along lake margins during the past 60 years will be evaluated relative to early Holocene thermokarst lake emissions and projected permafrost carbon emissions by year 2100. The data will be placed in the context of large regional temperature increases in the Arctic, up to 7.5 °C by 2100, and thicker, organic-rich Holocene-aged deposits subject to thaw and aerobic decomposition as active layer deepens. We will report on the inflection of large permafrost carbon emissions that is imminently expected to occur and whether or not it has commenced.

References

Koven, C.D.; Schuur, E.A.G.; Schädel, C.; Bohn, T.J.; Burke, E.J.; Chen, G.; Chen, X.; Ciais, P.; Grosse, G.; Harden, J.W.; Hayes, D.J.; Hugelius, G.; Jafarov, E.E.; Krinner, G.; Kuhry, P.; Lawrence, D.M.; MacDougall, A.H.; Marchenko, S.S.; McGuire, A.D.; Natali, S.M.; Nicolsky, D.J.; Olefeldt, D.; Peng, S.; Romanovsky, V.E.; Schaefer, K.M.; Strauss, J.; Treat, C.C. and Turetsky, M. [2015]: A simplified, data-constrained approach to estimate the permafrost carbon–climate feedback. *Trans. R. Soc. A*, 373, doi:10.1098/rsta.2014.0423.

Schneider von Deimling, T.; Grosse, G.; Strauss, J.; Schirrmeister, L.; Morgenstern, A.; Schaphoff, S.; Meinshausen, M. and Boike, J. [2015]: Observation-based modelling of permafrost carbon fluxes with accounting for deep carbon deposits and thermokarst activity. *Biogeosciences*, 12(11):3469–3488, doi:10.5194/bg-12-3469-2015.

Walter Anthony, K.; Daanen, R.; Anthony, P.; Schneider von Deimling, T.; Ping, C.-L.; Chanton, J. and Grosse, G. [submitted]: Ancient methane emissions from 60 years of permafrost thaw in arctic lakes.