Global Warming Feedbacks from Methane Bubbling along Expanding North Siberian Lake Margins

K.M. Walter[1], D.A. Draluk[2], S.A. Zimov[2], J.P. Chanton[3], F.S. Chapin III[1]

[1]Institute of Arctic Biology, P.O. Box 757500, University of Alaska, Fairbanks, 99775-0700;
907-474-7929, Fax: 907-474-6967; E-mail: ftkmw1@uaf.edu
[2]Northeast Science Station, Cherskii, Russia
[3]Florida State University, Tallahassee

Ebullition is often the dominant pathway of methane release from aquatic ecosystems, yet it has seldom been carefully measured due to heterogeneity in the spatial distribution and episodic release of gas bubbles. This likely results in an underestimation of total methane emission.

We took advantage of ice formation over lake surfaces in northeastern Siberia to map patterns of methane bubbles trapped in lake ice. We located "hot-spot" ebullition sites as holes in the ice that remain open throughout winter because of exceptionally high rates of bubbling methane. Through random and selective placement of underwater under-ice chambers we measured "background" and "hot-spot" fluxes annually. The combination of mapping and chamber measurements among different types of thermokarst lakes enabled us to (1) improve estimates of methane emissions from northeastern Siberian lakes, and (2) identify thermokarst erosion as a landscape process that enhances methane production and emission.

Ebullition comprised 96% of total methane emission from lakes. Hotspot sites, which occurred along thermokarst margins, released up to 10 g m^{-2} of CH_4 per day. Extrapolation of our bubbling methane measurements to all North Siberian thermokarst lakes would increase the estimate of methane emissions from northern latitude ecosystems by 15-40%!

Thermokarst lakes in North Siberia comprise a large proportion of the world's high latitude lakes, yet they are understudied. Melting of ice-rich (50-90% ice) permafrost soil along lake margins (thermokarst erosion) deposits organic-rich (~2%) mineral soil into anaerobic lake bottoms, providing a fresh, labile substrate for methanogenesis. Stable isotope and radiocarbon age dating of methane bubbles reveal the importance of Pleistocene-age organic matter as a source for methane production in lake sediments. Increased thermokarst erosion with climate warming would provide a positive feedback to methane production and emission from lakes. Results from this study suggest ebullition may be a more important pathway of methane emission from aquatic ecosystems than previously reported.