Biogeochemical Controls on Microbial CO_2 and CH_4 Production in Polygonal Soils From the Barrow Environmental Observatory

Terrestrial Ecosystem Science Program: NGEE-Arctic Project (PI: Wullschleger)

David E. Graham[1], Taniya Roy Chowdhury[1,4], Elizabeth M. Herndon[2,5], Ziming Yang[2], Liyuan Liang[2], Baohua Gu[2], and Stan D. Wullschleger[2,3]

(1) Biosciences Division, Oak Ridge National Laboratory, Oak Ridge, TN

(2) Environmental Sciences Division, Oak Ridge National Laboratory

(3) Climate Change Science Institute, Oak Ridge National Laboratory

(4) Present Address: Pacific Northwest National Laboratory, Richland, WA

(5) Present Address: Kent State University Kent Campus, Kent, OH

Contact: D. Graham (grahamde@ornl.gov)

Organic matter buried in Arctic soils and permafrost will become accessible to increased microbial degradation as the ground warms due to climate change. The rates of organic matter degradation and the proportion of CH_4 and CO_2 greenhouse gasses depend on the microbial response to warming, organic carbon structure and availability, the pore-water quantity and geochemistry, and available electron acceptors. To adapt and improve the representation of these Arctic subsurface processes in terrestrial ecosystem models for the NGEE Arctic project, we examined SOM transformations from elevated and subsided areas of low- and high- centered polygons from interstitial tundra on the Barrow Environmental Observatory (Barrow, AK). Significant amounts of iron(II) ions in most organic and mineral soil horizons features indicate that newly thawed organic matter will be released into anoxic conditions. Using microcosm incubations at fixed temperatures and controlled thawing systems for frozen soil cores, we investigated the microbiological processes and rates of SOM degradation and greenhouse gas production under anoxic conditions, at ecologically relevant temperatures of -2, +4 or +8 °C. Incubated soils from low-centered polygons produced substantially more CH_4 and CO_2 than soils from corresponding positions of high-centered polygons regardless of water saturation, indicating additional controls on SOM degradation. Substantial differences in CH_4 and CO_2 response curves from different microtopographic samples separate the thermodynamic controls on biological activity from the kinetic controls of microbial growth and migration following thaw that together determine the temperature response for greenhouse gas emissions in a warming Arctic.