Effects of Spatial Variation and Microtopography on Methane Production in the Siberian Arctic Tundra

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Introduction

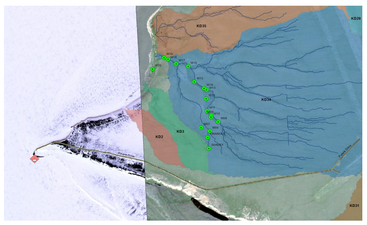
In the Arctic tundra, methane production from upland soils is generally assumed to be low due to environmental conditions unfavorable for methanogenesis. As temperatures rise, however, permafrost thaw may alter topography and vegetation type, creating soil conditions more favorable to methane production and increase methane flux. If so, extensive thawing could be a positive feedback on global warming, increasing production of methane and other greenhouse gases which can further increase global temperatures.

Objectives

Assess how methane production in ponds changes with landscape position along an elevation gradient.

Investigate the impact of variation in soil moisture on methane flux from a range of microenvironments in upland tundra in the East Siberian Arctic.

(a)



(b)

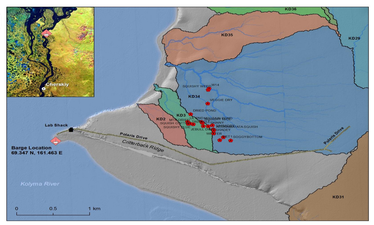


Figure 1:

(a) Ponds used to assess changes along an elevation gradient.

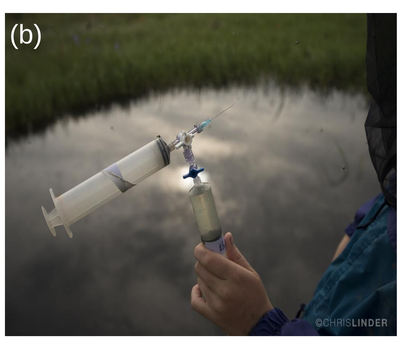
(b) Micro-environments used to assess variation in soil moisture flux.

Methods

Used chambers (a) to measure surface methane fluxes in the field from microenvironments ranging from ponds, to moss dominated saturated soils, to dry soils dominated by sedge.

Measured dissolved methane in water samples from ponds using a standard head-space method (b).

Estimated methane production in soil samples from each micro-environment using anaerobic incubation experiments (c).



Results

Watershed elevation gradient (Fig. 1a)

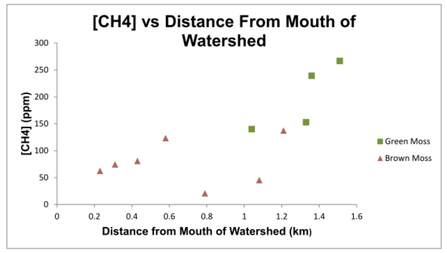


Figure 3: Distance from the mouth of the watershed and the concentration of dissolved methane in pond water.

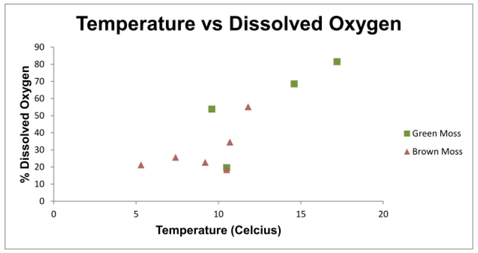


Figure 4: Relationship between the surface temperature of the pond and the percent dissolved oxygen (R^2= 0.659).

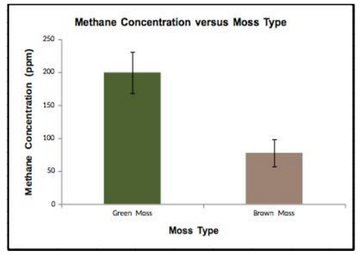
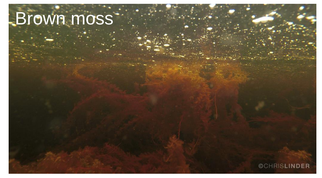


Figure 5: Methane concentrations in ponds with green moss and ponds with brown moss.



Methane Flux (Fig. 1b)

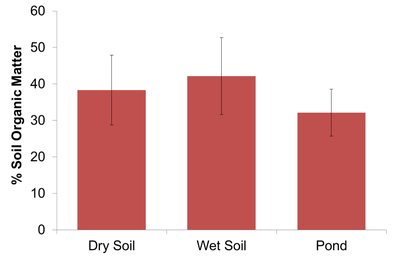


Figure 6: Organic matter content of each soil types.

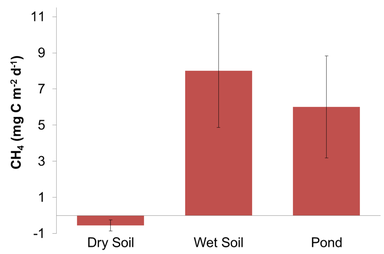


Figure 7: Methane flux from surface of three different micro-environment.

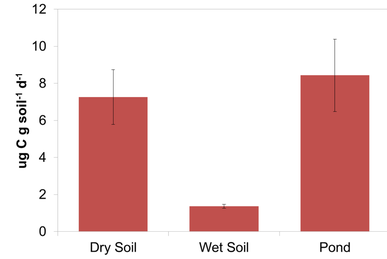


Figure 8: Methane production from soil incubations.

Conclusions

- Methane flux is clearly linked to soil saturation, which suggests the impact of permafrost thaw on future methane flux will depend on the extent of change in microtopography
- Average methane concentrations were lower in ponds with brown moss, at the bottom of the landscape. Previous studies in similar climatic regions suggest that brown moss may host methanotrophic bacteria that oxidize the methane at the surface of the soil within the ponds (Liebner et al. 2011).
- Soil incubation experiments suggest that soils from the bottom of the ponds and dry patches have a higher potential for methanogenesis under the anoxic conditions of the experiment. This suggests extensive potential for methane production under warming scenarios that lead to land slumping and increased extent of soil saturation.

Literature Cited

Leibner, S., J. Zeyer., D. Wagner., C. Schubert., E.M. Pfeiffer., and C. Knoblauch. 2011. Methane oxodiation associated with submerged brown mosses reduces methane emissions from Siberian polygonal tundra. Journal of Ecology 99:914-922. Doi: 10.1111/j.1365-2745.2011.01823