EGU21-15327
https://doi.org/10.5194/egusphere-egu21-15327
EGU General Assembly 2021

The role of methane transport from the active layer in sustaining methane emissions and food chains in subarctic ponds

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Shallow groundwater flow from the seasonally thawed active layer is increasingly recognized as an important pathway for delivering methane (CH_4) into Arctic lakes and streams, but its contribution to CH_4 emissions from thaw ponds has not been evaluated. Furthermore, the potential influence of the shallow groundwater-derived CH_4 on the trophic support and nutritional quality of thaw pond food chains remains unexplored. In this study, we used a radon-mass balance approach to quantify the CH_4 transport from the active layer into thaw ponds in a sub-Arctic catchment. We analysed stable isotopes and fatty acids of pond macroinvertebrates to evaluate the potential effects of CH_4 inputs through active layer groundwater flows on the aquatic food chains. Our results indicate that CH_4 fluxes from the active layer can sustain CH_4 emissions from the ponds. Consumers in ponds receiving greater CH_4 inputs from the active layer had lower stable carbon isotope signatures that indicates a greater trophic reliance on methane oxidizing bacteria (MOB), and they had lower nutritional quality as indicated by their lower tissue concentrations of polyunsaturated fatty acids. Accurate predictions of CH_4 release from small thaw ponds will thus require improved knowledge of the contributions from various processes including internal production, flow paths of active layer groundwater, and MOB-consumer interactions.