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# Long-term versus short-term warming effects on microbial processes

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Rapid warming in high latitude ecosystems is predicted to drive massive losses of carbon dioxide ($CO_2$) from soils to the atmosphere, raising concerns that it will create a positive feedback to climate change. However, such predictions expect that temperature effects on soil microbes, as chief producers of $CO_2$, will persist over time scales meaningful to the climate system (i.e. decades to centuries). There is increasing awareness that the soil microbial community can acclimate to temperature change over time scales from months to years, resulting in attenuating responses of $CO_2$ release to the atmosphere. Despite this, nothing is currently known about long-term warming effects on the activity or physiology of high latitude soil microbes, and, through this, the longevity of $CO_2$ losses from these ecosystems. We conducted a study at a unique research site that makes use of natural (geothermal) gradients in soil temperature that have been in place for over 35 years as a natural warming treatment. We determined long-term warming effects (+0.5 °C, +1.5 °C, +3 °C and +6 °C) on soil $CO_2$ release through microbial respiration in a laboratory incubation experiment, and explored microbial carbon use efficiency and soil carbon and nitrogen pools as mechanisms. We also performed a companion experiment to compare long-term warming effects on microbial processes to those caused by six weeks of warming of ambient soil to +3 °C and +6 °C. We show that while six weeks of warming consistently increased microbial respiration by up to 30%, this effect did not persist in soils exposed to 35 years of warming. We present further data linking such long-term thermal acclimation to shifts in microbial carbon use efficiency and soil carbon and nitrogen availability, and discuss our findings in the context of warming-driven feedbacks from high latitude soils to future climate change.