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Circumpolar assessment of organic matter decomposability as a control over potential permafrost carbon loss with climate change

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High latitude ecosystems store approximately 1700Pg of soil carbon (C) which is twice as much carbon than currently contained in the atmosphere. Permafrost thaw along with microbial decomposition of permafrost organic matter could add large amounts of C to the atmosphere, thereby influencing the global C cycle. The rate at which C is being released from the permafrost zone at different depths and across different physiographic regions is poorly understood but crucial in understanding future changes in permafrost C storage with climate change. We assessed the inherent decomposability of permafrost carbon once thawed by assembling a database of long-term (>1year) aerobic soil incubations from 126 individual cores from 39 different high latitude ecosystems located across the northern circumpolar permafrost zone. Soil incubation data sets used in this analysis were obtained from participants of the C quality working group which are part of the Vulnerability of Permafrost Carbon Research Coordination Network9 or extracted from the literature. Using a 3-pool decomposition model, we estimated decomposition rates and pool sizes for C fractions with different turnover times using a reference temperature of 5°C. Fast cycling C accounted for less than 5% of all C in organic and mineral soils whereas the pool size of slow cycling C increased with C:N ratio. Stable C was particularly high in deep mineral soils and accounted for up to 90% of the total C in these soils. Turnover times of fast cycling C typically ranged below one year, between 5-15 years for slow turning over C and more than 500 years for stable C. We scaled up potential C loss from these high latitude soils over time and estimated that between 20-90% of the organic C in the incubation could be lost when projected over a 50 year time period with the higher vulnerability of C loss in soils with high C:N ratios at the 5°C reference temperature. These results demonstrate the vulnerability of C stored in permafrost to increasing temperatures, and importantly show that the wide range of potential loss significantly correlates with C:N ratio, which needs to be incorporated in to models projecting permafrost C loss.

9http://www.biology.ufl.edu/permafrostcarbon/