

Circumpolar assessment of permafrost C quality and its vulnerability over time using long-term incubation studies

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High latitude ecosystems store approximately 1700Pg of soil carbon (C), which is twice as much C as is currently contained in the atmosphere. Permafrost thaw and subsequent microbial decomposition of permafrost organic matter could add large amounts of C to the atmosphere, thereby influencing the global C cycle. The rates at which C is being released from the permafrost zone at different soil depths and across different physiographic regions are poorly understood but crucial in understanding future changes in permafrost C storage with climate change. We assessed the inherent decomposability of permafrost C once thawed by assembling a database of long-term (>1year) aerobic soil incubations from 121 individual cores from 23 high latitude ecosystems located across the northern circumpolar permafrost zone. Using a 3-pool decomposition model, we estimated pool sizes for C fractions with different turnover times and their inherent decomposition rates 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 increasing C:N ratio. The stable C pool was particularly large 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. With our findings we scaled up potential C loss from these high latitude soils over time and calculated that between 20-90% of the organic C in the studied soils could be lost within 50 years with the highest vulnerability to loss in soils with high C:N ratios. These results demonstrate the vulnerability of C stored in permafrost to increasing temperatures, and 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.