Estimate of permafrost organic carbon balance in Alaskan boreal and tundra ecosystems using natural level radiocarbon

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The high-latitude regions, where a serious warming is expected, currently store large amounts of soil organic carbon (SOC) in active-layer soils and permafrost, accounting for nearly half of the global belowground organic carbon pool. Despite the importance of these regions in the present carbon cycle, the soil C fluxes and budget are still only poorly known. Here, we use radiocarbon as the tool for quantifying the C balance of the inputs and decomposition in tundra and boreal soil. We evaluated the C inputs (I) and decomposition rates (k, inverse of turnover time) and net C accumulation (CA), using ^{14}C approaches.

Tundra and boreal soils show different patterns of depth distribution and C storage. Cumulative organic carbon stocks in boreal forest are 5.3 and 19.2 $kgCm^{-2}$, in surface organic layer (0-25 cm), and deep organic and mineral layers (25-70 cm), respectively. Large annual C input (0.249 $kgCm^{-2}\ yr^{-1}$) and relatively slow decomposition (27 years) lead to rapid CA (0.052 $kgCm^{-2}\ yr^{-1}$) in surface organic layer in boreal forest. Deep organic and mineral layers including near-surface permafrost show slower rate of input (0.031 $kgCm^{-2}\ yr^{-1}$) and turnover (617 years) and CA about 20 times slower (0.003 $kgCm^{-2}\ yr^{-1}$) than surface organic layer. Decomposition organic matter (Rh), which in accord with C losses from both surface and subsurface layers, was 0.225 $kgCm^{-2}\ yr^{-1}$. This value agreed well with Rh (0.227 $kgCm^{-2}\ yr^{-1}$) simulated by process-based models that simulate the biogeochemical and hydrologic cycle, where Rh averaged 45% of ecosystem respiration and 59% of soil respiration[2]. In contrast, large amount of SOC (36.4 kg m^{-2}) have accumulated over millennia (turnover time: 4540 yrs) below the thin organic layer in tundra. The CA of mineral layer and permafrost is close to zero (0.003 $kgCm^{-2}\ yr^{-1}$), and Rh is 0.008 $kgCm^{-2}\ yr^{-1}$. Our radiocarbon data show that the most SOC in tundra soil was mode of stabilizing OC by permafrost and steady-state SOC stocks under current C balance.

References

1. Ueyama M., Y. Harazono, Y. Kim and N.Tanaka, Response of the carbon cycle in sub-arctic black spruce forests to climate change: Reduction of a carbon sink related to the sensitivity of heterotrophic respiration, Agric. For. Meteorol., 149, 582–602, 2009.