Geophysical Research Abstracts
Vol. 19, EGU2017-1150-1, 2017
EGU General Assembly 2017

The origin of soil organic matter dictates its composition and bioreactivity across a mesic boreal forest latitudinal gradient

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Climate transect studies and soil warming experiments have shown that soil organic matter (SOM) formed under a warmer climate is typically more resistant to microbial decomposition, as indicated by lower decomposition rates at a given temperature (bioreactivity). However, it remains unclear how climate impacts SOM via its effect on vegetation and thus litter inputs to soils, or on decomposition and thus how SOM changes over time (diagenesis). We addressed this question by studying how the chemical and biological properties of SOM vary with decomposition (depth) and climate history (latitude) in mesic boreal forests of Atlantic Canada.
SOM bioreactivity, measured in a 15-months decomposition experiment, decreased from cold to warm regions, and from the topmost (L) to the deepest horizon studied (H). The variations in SOM bioreactivity with climate history and depth, however, were associated with distinct parameters of SOM chemistry. More decomposed SOM with depth was associated with lower proportions of %N as total hydrolysable amino acids (THAA), and a different THAA-based degradation index signifying a more degraded state. However, SOM from the warmer region exhibited higher lignin to carbohydrate ratios, as detected by NMR. None of the measured parameters associated with regional differences in SOM chemistry increased with depth. Together, these results indicate that the regional differences in SOM chemistry and bioreactivity in these soils did not result from significant differences in the degree of degradation, but rather resulted from chemically distinct litter inputs.
The comparison of SOM and plant litter chemistry allowed us to identify how climate affects litter inputs in these forests. Vascular plant litter collected in litter traps, unlike SOM, exhibited largely similar chemical composition across all transect regions. Litter traps, however, do not collect moss litter, which is chemically distinct from vascular plant litter. We, therefore, assessed the proportions of identifiable moss to vascular plant material in the L horizon, and found that the proportion of moss litter decreases from north to south consistent with moss cover estimates across this transect. Furthermore, SOM was more similar to vascular plant litter in more southern sites, while properties of moss litter (high carbohydrate, low lignin and plant wax concentrations) were associated with the more bioreactive SOM found in the northern sites. Despite the slow rates of moss litter decomposition relative to vascular plant litter observed in many studies, these results suggest that moss derived SOM is decomposed more rapidly than vascular plant derived SOM. This is consistent with (1) initially rapid decomposition of vascular plant litter contributing to more slow turnover SOM, and (2) the role of antimicrobial compounds in reducing surface moss litter decomposition which may be reduced at depth due to their removal or inactivation over time.
The decrease of SOM bioreactivity due to lower proportions of moss inputs in the warmer forests studied here signifies an important and understudied ecosystem mechanism that can control the cycling of C in these, and likely other boreal forest soils in a warmer future.