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A tale of two seasons: Winter and autumn hydroclimatic linkages impact soil carbon mobilization and stores in warming humid boreal forest landscapes

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Terrestrial-to-aquatic fluxes of dissolved organic matter (DOM), important components of landscape C balance, are hypothesized to increase with climate change in boreal forests. Humid boreal forests hold vast stores of soil C in mineral podzolic soils perched on top of compacted till and underlying thick, conductive moss and organic layers. This structure results in perched water storage components influencing the hydrobiogeochemical processes controlling soil DOM fate. By coupling interannual, seasonal, and event-based studies of DOM mobilization and composition from pedon to small catchment scales, we develop hypotheses probing climate change impacts on DOM fate in humid boreal forest landscapes.

In the maritime boreal region of Newfoundland and Labrador, enhanced soil DOM mobilization from surface organic horizons is attributed to warmer winters, less so increased precipitation. Chemical composition of DOM indicates the increased flux in warmer winters is due to reduced microbial decomposition caused by shorter snowpack duration. On an annual basis this may result in a shift toward less-degraded DOM retained in underlying mineral soils or lost to aquatic systems. Experimental results indicate less-degraded DOM mobilized from surface organic soils is preferentially retained via sorption to organo-metal complexes in the underlying mineral soils. The extent and depth of DOM retention depend on the degree of infiltration relative to surface and lateral flows. Regional trend analyses indicate increasing winter precipitation and runoff but stable runoff ratios, indicating enhanced winter infiltration. Headwater catchment hydrology further suggests wetter winters increase perched soil water storage in the subsequent autumn. Impact of this storage is modulated by autumn precipitation, controlling the extent and timing of subsurface flow paths through C-rich soil layers potentially enhancing autumn DOM export.

Our results suggest winter-autumn hydrologic interactions are key to understanding mineral soil C stores and DOM export in these systems. Warmer, wetter winters enhance mobilization of surface soil DOM with potential to enhance mineral soil C stores through increased infiltration of less degraded DOM. Determining how autumn shallow subsurface flow paths, evolving from winter-autumn hydroclimate interactions, promote DOM export will inform a predictive understanding of warming impacts on mineral soil C storage in these humid boreal forest landscapes.