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Linking Composition of Extractable Carbon from Active Layer Soils with Thaw Depth

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Introduction:

As the climate warms and the depth of ground thaw increases in Arctic watersheds, hydrologic flow-paths that connect terrestrial and aquatic ecosystems are likely to deepen as well, increasing the relative importance of subsurface flow vs. surface runoff (1).

In addition, as permafrost begins to thaw, carbon and nutrients previously locked in frozen soils will become available for processing and transport (2), potentially altering the flux of organic matter from subsurface sources to benthic sediments and surface waters of small streams (3).

Assessing the possible impact of this material on stream ecosystems requires knowledge on the total amount, composition, and lability of carbon likely to be leached from thawed permafrost, and how the nature of it will change as ground thaw deepens.

Objective:

To investigate the implications of increasing thaw depth for chemical composition of subsurface water in an Arctic watershed.

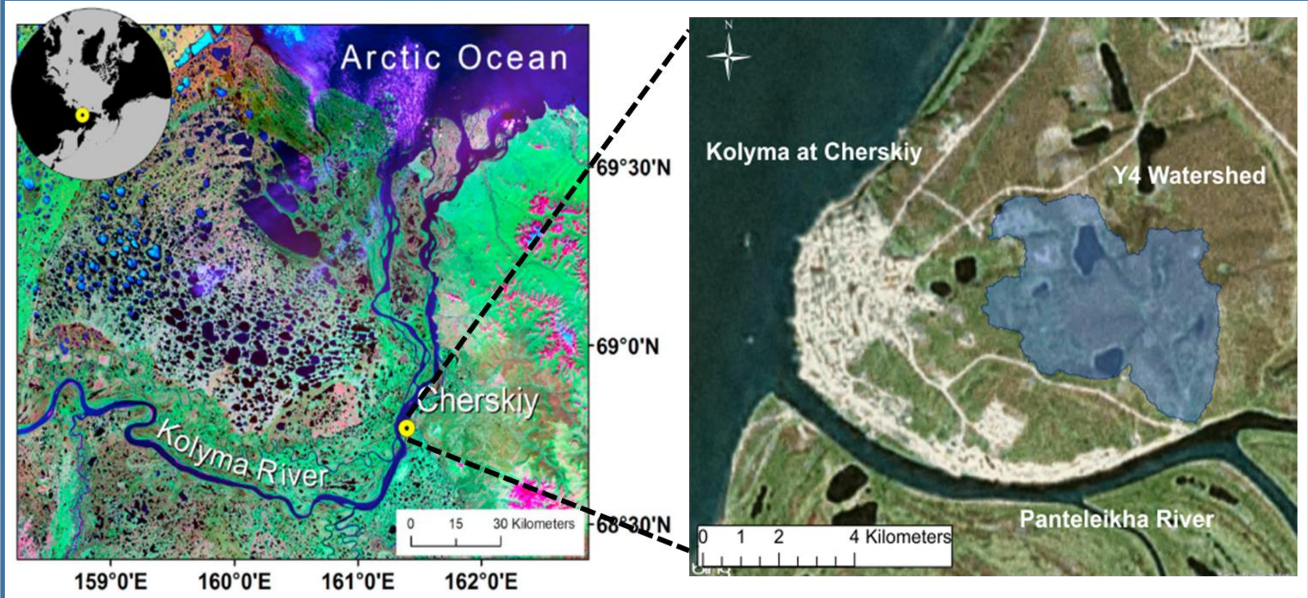


Figure 1 – This research was conducted in the Y4 watershed, a small subcatchment of the Kolyma River adjacent to the Northeast Science Station near Cherskiy, Russia.

Figure 2– Six sites were sampled adjacent to the Y4 stream channel that varied in thaw depth. At each site, beginning 50 cm away from the channel, 9 thaw depths were recorded in a 1 square meter plot.

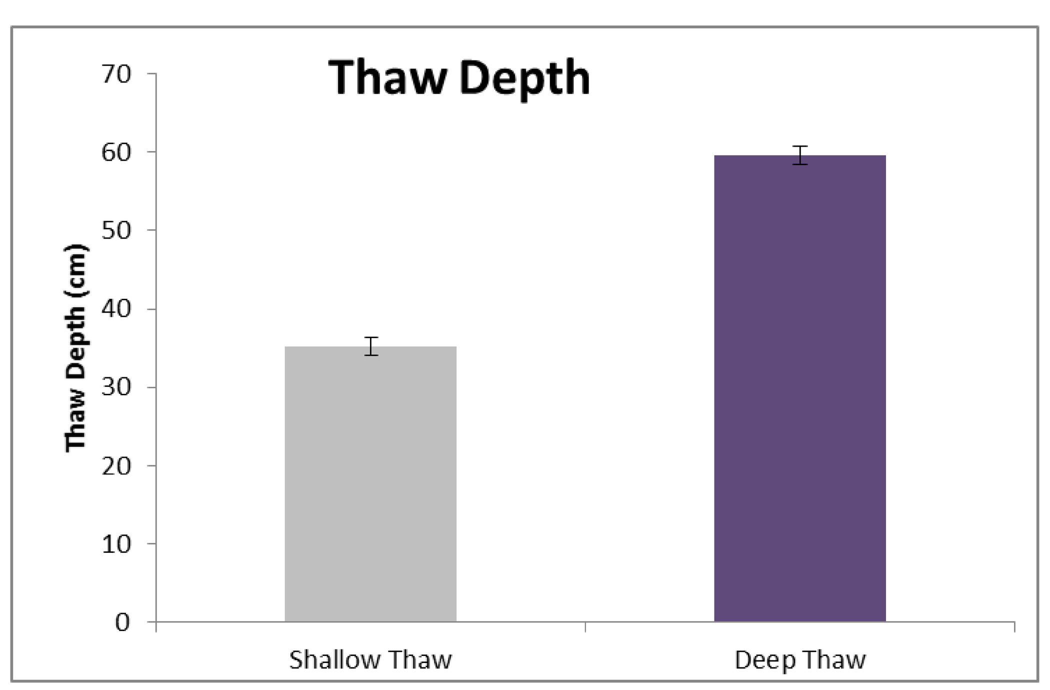
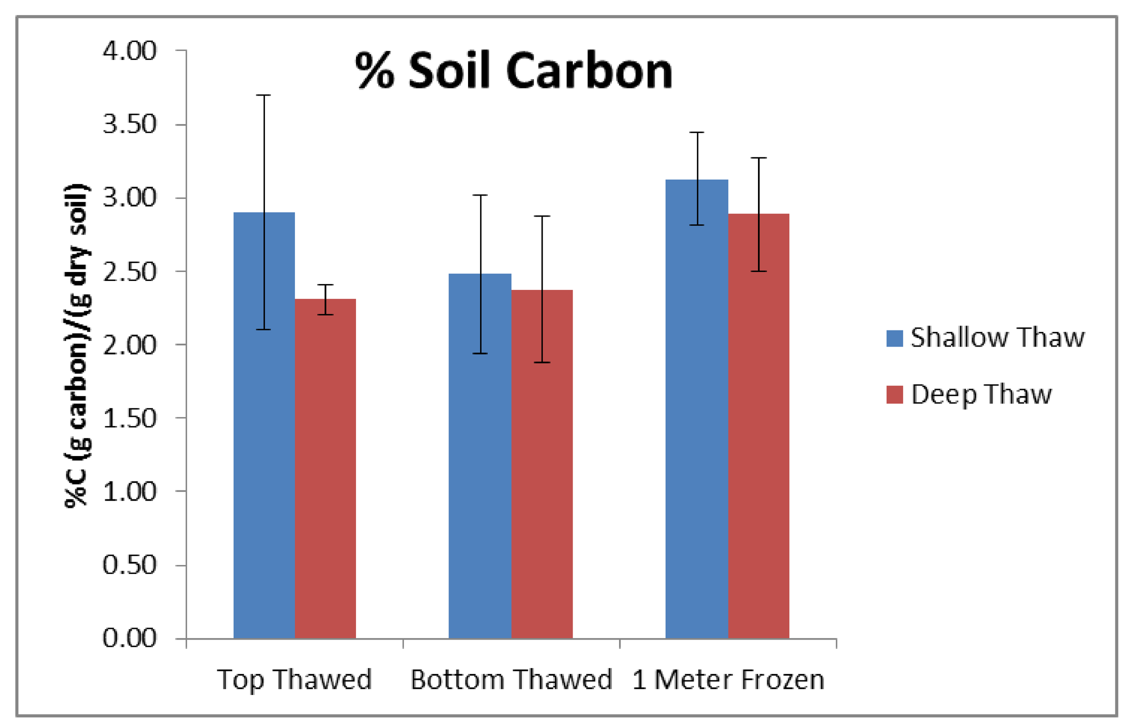
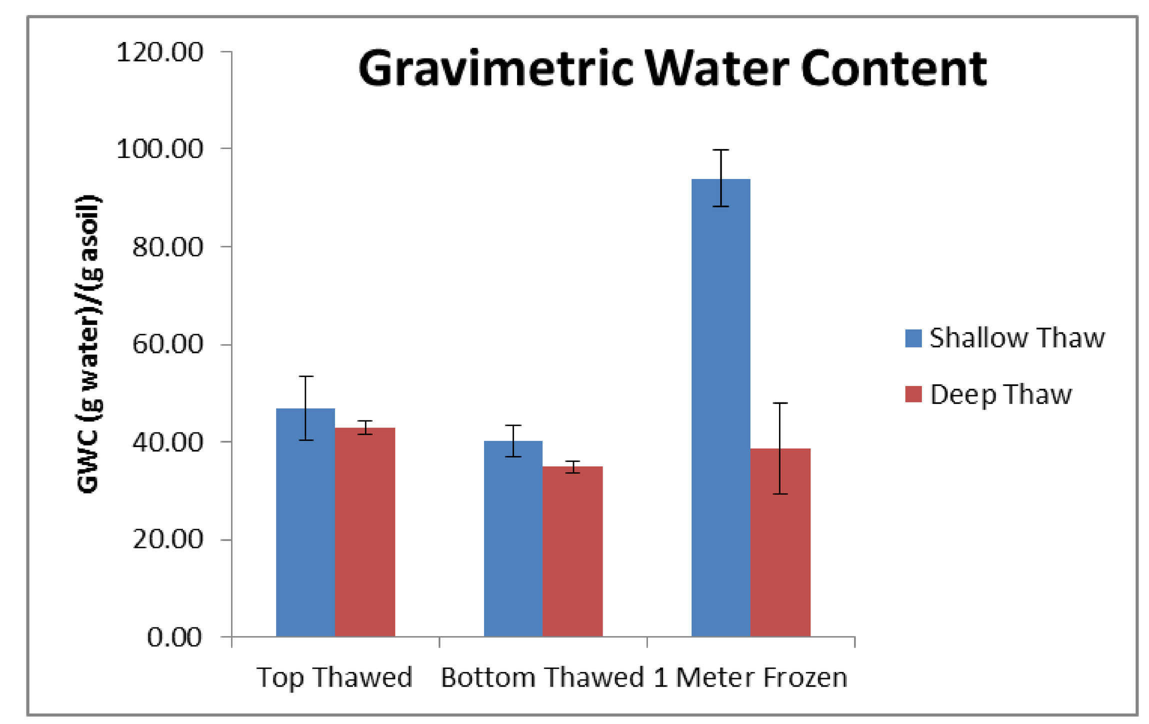


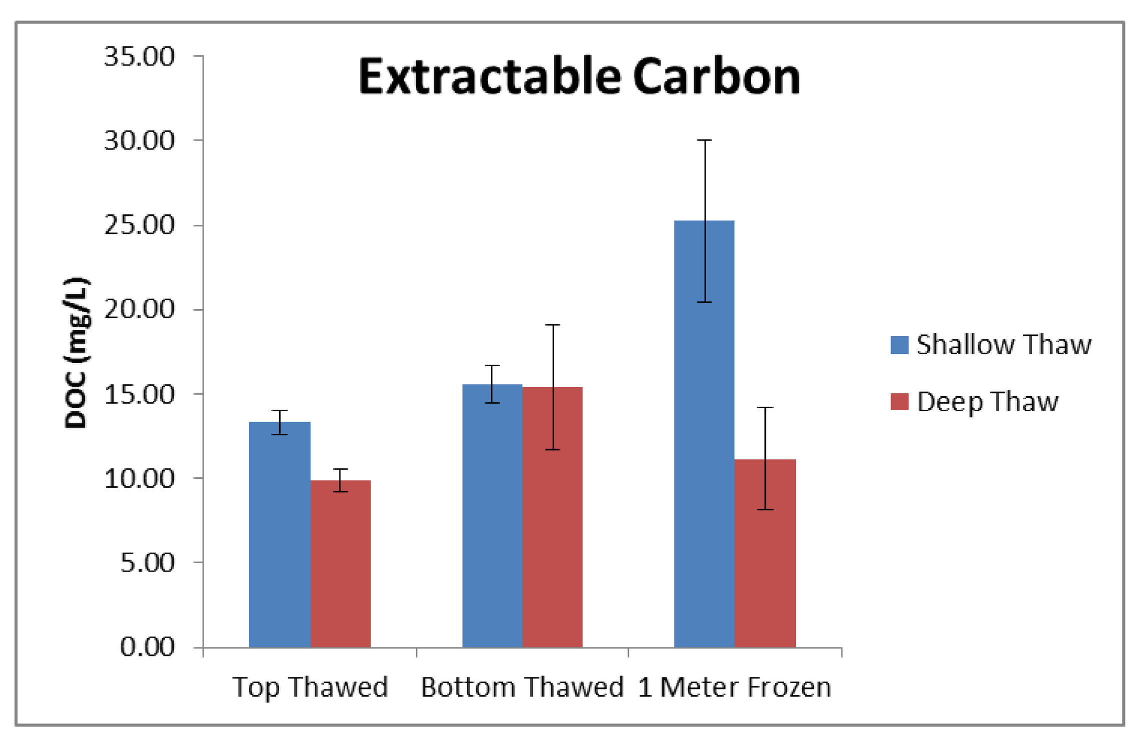
Figure 3 – 1-m-deep soil cores were collected approximately in the center of the plot at sites, and subsamples were taken from the top and bottom of the thawed mineral and from frozen soil 1 m below the surface.

Laboratory Methods:

Subsamples from each soil fraction were dried for gravimetric water content, and ashed to estimate organic matter and carbon content. A second set of subsamples of each soil fraction were leached with distilled water then filtered and analyzed for amount and lability of dissolved organic carbon (DOC) to assess what might be transported to the stream.







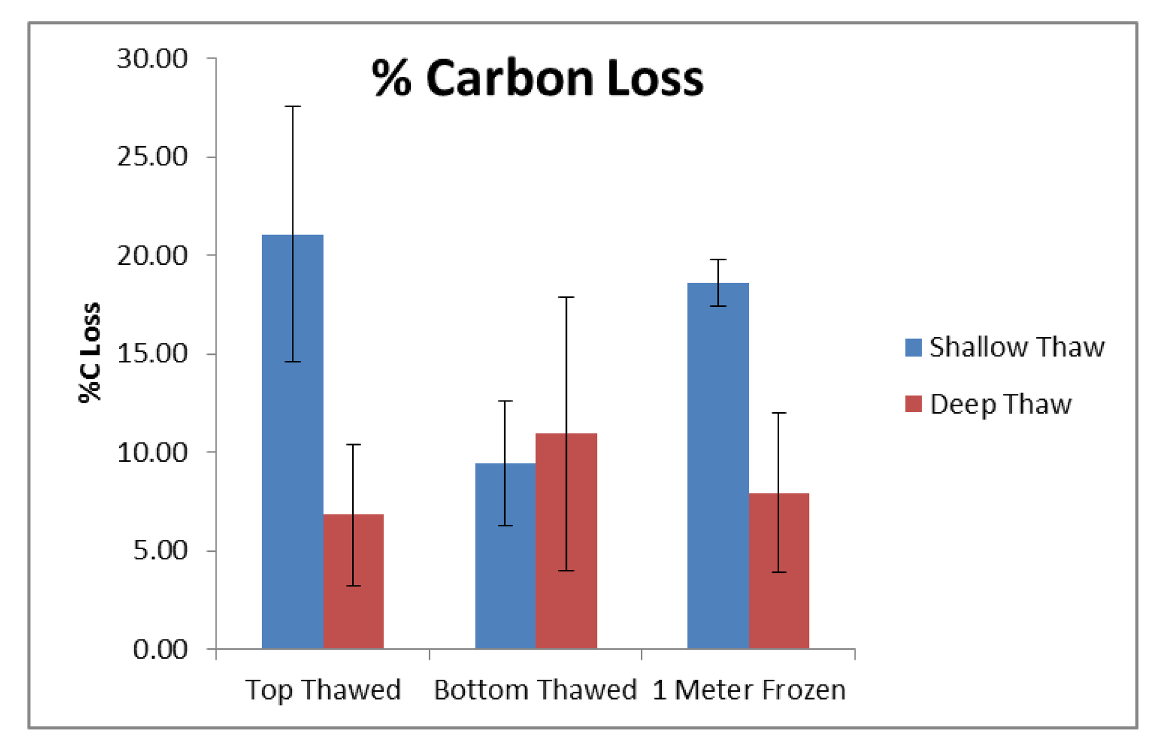


Figure 4: We found no difference in % soil carbon between thaw depths in any soil fractions, or in gravimetric water content for thawed mineral soils. Soils from the bottom of the thawed mineral soil showed no difference in amount or lability of carbon. Frozen soils from 1 m depth were higher in water content in shallow than deep thaw depth. In addition, soils from the top of the thawed mineral and from 1 m deep frozen fractions showed both higher concentration and lability in shallow thaw than deep thaw.

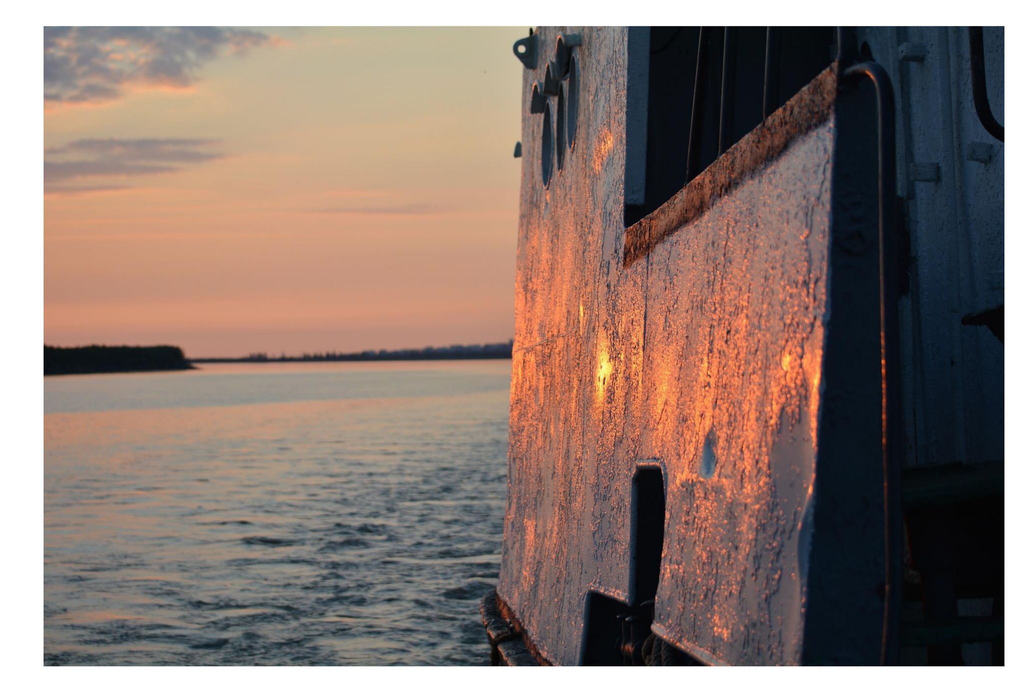
Conclusion:

- Sites with shallow vs. deep thaw showed substantial variation in the amount and lability of extractable organic carbon that could potentially be transported to the stream.

- This result suggests that as thaw deepens due to climate warming, small streams may receive larger inputs of labile carbon, with potentially important consequences for microbial communities, carbon processing, and gas flux from stream ecosystems in the Arctic.

- We hypothesize that frozen soils from sites with shallow thaw depth leached more labile carbon because they thaw less frequently and for shorter periods, leaving less time for microbes to process organic matter, resulting in longer term storage of labile organic matter.

- Soils from the top of the mineral layer also showed higher lability when thaw depth was shallow, which may be due to the same mechanism hypothesized above, or may result from early thaw and leaching of modern organic matter deposited on the soil surface the previous fall.



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