The Ephemeral Signature of Permafrost Carbon in an Arctic Fluvial Network

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Introduction

Arctic fluvial networks process, outgas, and transport significant quantities of terrestrial organic carbon (C), particularly dissolved organic carbon (DOC). The proportion of permafrost C in these fluxes, however, is poorly constrained. A primary obstacle to the quantification of permafrost-derived DOC is that it is rapidly respired without leaving a unique tracer of its presence.

Results and Discussion

In this study, we investigated the production of bacterial respiratory carbon dioxide (CO2; measured as dissolved inorganic carbon; DIC) during maximum late-summer thaw in sites spanning a fluvial network (Kolyma Basin, Siberia) to assess whether the biodegradation of permafrost DOC could be detected by the presence of a persistent aged (14C-depleted) signature on the DIC pool. Using Keeling plot interpretation of DIC produced in bioincubations of river water, we show that bacteria respire varying sources of DOC moving downstream through the fluvial network. Respiration of permafrost (production of aged CO2) was only detected in heavily permafrost thaw influenced sites. In nonpermafrost thaw impacted sites, ambient DIC was modern (14C-enriched), but rather than precluding the respiration of permafrost OC upstream, we suggest that 14C-depleted DIC is overwhelmed by modern DIC. Investigation of dissolved organic matter composition via Fourier transform ion cyclotron resonance mass spectrometry highlighted that elevated levels of aliphatic and nitrogen-containing compounds were associated with the production of aged DIC (Fig. 1), providing molecular-level insight as to why permafrost-derived dissolved organic matter is rapidly respired. Overall, results from this study demonstrate the difficulty of tracing inputs of a highly reactive substrate to systems with diverse organic matter sources.

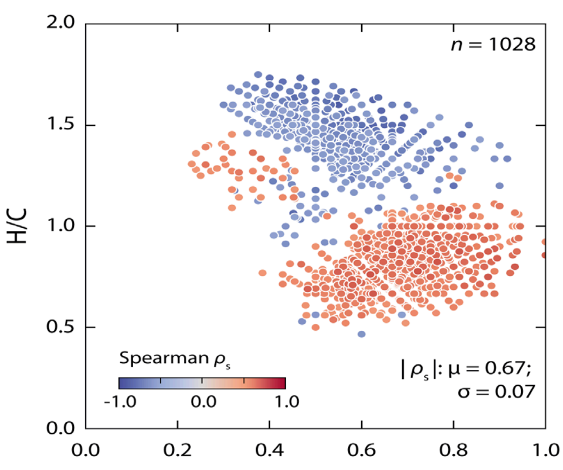

Fig.1 Van Krevelen plot of the Spearman rank correlation coefficients (ρs) between relative intensity and respiratory Δ^{14}C-dissolved inorganic carbon (DIC) for molecular formulae present in all samples throughout the fluvial network. Only formulae that exhibit a statistically significant correlation with Δ^{14}C-DIC are shown (P value ≤ 0.05, n = 1,028). Formulae with negative ρs values (blue) exhibit higher intensities in samples with lower respiratory Δ14C-DIC values, while formulae with positive ρs values (red) exhibit the opposite. The mean of the absolute value of ρs for all plotted formulae was 0.67, and the standard deviation was 0.07.

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References

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