Title

Using Stable Carbon Isotopes of Seasonal Ecosystem Respiration to Determine Permafrost Carbon Loss

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Deep-Wet) in a soil warming manipulation. Deep SOC loss was inferred from known $\delta^{13}C$ signatures of plant shoot, root, surface soil, and deep soil respiration. In addition, a 2-year-old vegetation removal treatment (No Veg) was used to isolate surface and deep SOC decomposition contributions to Reco. In No Veg, seasonal Reco$\delta^{13}C$ indicated that deep SOC loss increased as the soil column thawed, while in vegetated areas, root contributions appeared to dominate Reco. The Reco$\delta^{13}C$ differences between Shallow-Dry and Deep-Dry were significant but surprisingly small. This most likely suggests that, under dry conditions, soil warming stimulates root and surface SOC respiration with a negative ^{13}C signature that opposes the more positive ^{13}C signal from increased deep SOC respiration. In Deep-Wet conditions, Reco$\delta^{13}C$ suggests reduced deep SOC loss but could also reflect altered diffusion or methane (CH_4) dynamics. Together, these results demonstrate that frequent Reco$\delta^{13}C$ measurements can detect deep SOC loss and that plants confound the signal. In future studies, soil profile $\delta^{13}C$ measurements, vegetation removal across thaw gradients, and isotopic effects of CH_4 dynamics could further deconvolute deep SOC loss via surface Reco.

Plain Language Summary

Carbon (C) stored in permafrost soil is like a global savings account that keeps C out of the atmosphere. Arctic warming makes permafrost soil C vulnerable to microbial decomposition, and C released to the atmosphere would accelerate global warming. In this study we used ^{13}C isotopes, which function like molecular fingerprints, to detect permafrost soil C decomposition from a soil warming experiment that doubled the thawed soil volume and changed soil moisture conditions. We found that permafrost soil C decomposition was best detected when vegetation was removed. Deeper thaw depth had only a small effect on isotopic signatures possibly because the signal from higher permafrost soil C decomposition was overwhelmed by a simultaneous increase in surface soil decomposition and respiration from plants. In wet areas, the isotopic signal changed which could imply reduced permafrost soil C decomposition. In wet areas, methane cycling might also change the isotope signature. We conclude that seasonal ^{13}C sampling could be useful for detecting permafrost soil C decomposition if combined with measurements that can isolate contributions from surface soil, roots, and methane cycling. Developing methods that make it easier to assess permafrost soil C decomposition is critical for estimating the balance of our global C savings account.