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Landscape variability of the stable carbon isotope composition of soil CO_2 concentrations and flux in complex terrain

Diego Riveros-Iregui (1), Liyin Liang (2), and David Risk (3)

(1) University of North Carolina at Chapel Hill, Geography, Chapel Hill, United States (diegori@unc.edu), (2) University of California Riverside, Botany and Plant Sciences, Riverside, CA, United States, (3) St. Francis Xavier University, Earth Sciences, Nova Scotia, Canada

Stable isotopes are commonly used to understand how physical and biological processes mediate the exchange of carbon between terrestrial ecosystems and the atmosphere. Numerous studies have described fundamental relationships between environmental variables, the carbon isotopic composition (δ13C) of recently assimilated sugars in plants, litter, soil carbon, or recently respired CO_2. However, studies that examine the landscape scale variability of the 13C content of forest soils are lacking. We report on measurements of the carbon isotopic composition of soil CO_2 concentrations (δ13CC) and flux (δ13CJ) across a subalpine forest of the northern Rocky Mountains of Montana, United States. Our analysis demonstrates that soil moisture and the lateral redistribution of soil water are strong predictors of the spatial variability of both δ13CC and δ13CJ at the watershed scale. Our analysis suggests that there are concomitant yet independent effects of soil water on physical (i.e. soil gas diffusivity) and biological (i.e. photosynthetic activity) processes that mediate the 13C composition of forest soils. We show systematic spatial variability in the δ13C of forest soils at the landscape scale that can be useful to accurately predict and model land-atmosphere CO_2 exchange over complex terrain.