Using soil organic carbon isotopes in C_3 dominated ecosystems to reconstruct ancient precipitation

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Due to the direct interaction between plants and their environments, $\delta^{13}C$ values of leaves ($\delta^{13}C_{leaf}$) have been used to reconstruct different aspects of ancient climate. In particular, these values have been linked to precipitation, as increased water availability allows plants to discriminate more against carbon ($\Delta^{13}C_{leaf}$ values). However, in previous work, we demonstrated that $\Delta^{13}C_{leaf}$ values are a plant trait, constant for a given species across its precipitation range[1-2]. Thus, site-level variation in modern studies reflects the $\Delta^{13}C_{leaf}$ variation within the community. We hypothesized that because soils aggregate all of the individual plant discrimination responses, $\delta^{13}C$ values of near-surface soil organic matter ($\delta^{13}C_{SOM}$) represent an average of aboveground biomass values. Thus, $\delta^{13}C_{SOM}$ values may be more representative of local precipitation than individual plant species. Separately, soil inorganic chemistry has been used to reconstruct precipitation, including techniques like chemical index of alteration (CIA), depth to carbonate horizon (depth to Bk), paleosol-paleoclimate model (PPM1.0, a nonlinear spline model), and others[3]. We tested the relationship between $\delta^{13}C_{SOM}$ values and mean annual precipitation (as well as other climate parameters) in modern C_3-dominated ecosystems (n = 152), finding a strong relationship. We tested this new proxy in the fossil record on sites with precipitation values that were reconstructed using the aforementioned established soil-based precipitation proxies, demonstrating that the $\delta^{13}C_{SOM}$–precipitation proxy reconstructed consistent mean annual precipitation values, particularly in lower rainfall regimes.

[1]Stein et al. (2019) *PeerJ* 7:e7378; [2]Sheldon et al. (2020) *Global and Planetary Change* 184:103060; [3]Lukens et al. (2020) *Am. J. Sci.* 319:819.