Representing microbial processing and mineral stabilization of plant-derived organic matter in models of terrestrial N isotopes

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Stable N isotopes provide insights into the factors shaping ecoystem and global N cycles, but their interpretation can depend on how ^{15}N and N are modeled. Many analyses simplify ecosystems with a 2-box model representing plant and soil N and ^{15}N pools without exploring the implications of this simplication, particularly for soils. Here, we examine an alternative formulation that separates soil N into two pools and treats plant N as an ephemeral flow at the timescale of interest. The revised model focuses attention on a pool of plant-derived free particulate organic matter (FPOM) in soil, and a second pool of mineral-associated organic matter (MAOM) stabilized following microbial processing of FPOM This separation into two pools is supported by diverse empirical data across soil aggregate size, density fractions, and soil depth, showing that mineral-associated organic matter (MAOM) displays characteristics associated with microbial processing and is enriched in ^{15}N relative to plants and FPOM. We evaluate the revised model's potential to better describe the global drivers of δ^{15}N in response to climate and soil properties using an expanded global dataset of soil δ^{15}N.

By treating soil N as two functionally distinct pools, our model suggests that low soil δ^{15}N values in wetter and cooler climates reflect high FPOM/MAOM ratios, with less microbial N processing. Because the revised model links most N losses to a fast plant-FPOM cycle (with lower δ^{15}N values), it also explains high soil δ^{15}N values in MAOM-dominated tropical soils without requiring enhanced gaseous N losses depleted in ^{15}N. Conclusions derived from the model therefore differ from previous global analyses. Perhaps most surprisingly, soil C and N pools of differing sensitivity to climate can thus be partitioned using δ^{15}N, without depending on complex methods such as modelling ^{14}C-derived soil C residence times.