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Partitioning nitrogen losses by natural abundance nitrogen isotope composition in a process-based statistical modelling framework

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Natural abundance of the stable isotope ^{15}N is an under-utilized resource for research on the global terrestrial nitrogen cycle. Mass balance considerations suggest that if reactive N inputs have a roughly constant isotopic signature, soil δ^{15}N should be mainly determined by the fraction of N losses by leaching – which barely discriminates against ^{15}N – versus gaseous N losses, which discriminate strongly against ^{15}N. We defined simple process-oriented functions of runoff (f_{runoff}) and soil temperature (f_{temp}) and investigated the dependencies of soil and foliage δ^{15}N (from global compilations of both types of measurement) on their ratio. Both plant and soil δ^{15}N were found to systematically increase with f_{temp}/f_{runoff}. Consistent with previous analyses, foliage δ^{15}N was offset (more negative) with respect to soil δ^{15}N, with significant differences in this offset between (from largest to smallest offset) ericoid, ectomycorrhizal, arbuscular mycorrhizal and non-mycorrhizal associated plants. δ^{15}N values tend to be large and positive in the driest environments and to decline as f_{runoff} increases, while also being lower in cold environments and increasing as f_{temp} increases. The fitted statistical model was used to estimate the gaseous fraction of total N losses from ecosystems (f_{gas}) on a global grid basis. In common with earlier results, the largest values of f_{gas} are predicted in the tropics and semi-arid subtropics. This analysis provides an indirectly estimated global mapping of f_{gas}, which could be used as an improved benchmark for terrestrial nitrogen cycle models.