

## Kinetic controls on isotopic fractionation of soil denitrification

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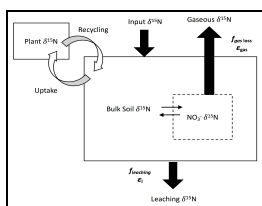
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### Isotopic Model of Nitrogen Gas Losses

Denitrification removes biologically available N from ecosystems and thus controls the biosphere's N balance, with implications for air quality, human health and climate change [1]. Estimates of the global soil denitrification flux are highly uncertain. Process-based models constrained by empirical isotopic evidence are as a key tool for quantifying this flux [2]. These models use the soil  $\delta^{15}\text{N}$  budget, soil moisture, and N input data, to quantify  $\text{NO}$ ,  $\text{N}_2\text{O}$  and  $\text{N}_2$  emissions from denitrification (figure 1). However, this method is limited by incomplete understanding of how isotopic expression of denitrification varies across known controls, including organic carbon (C) and nitrate ( $\text{NO}_3^-$ ) availability.



**Figure 1: Conceptual model of the controls on soil  $\delta^{15}\text{N}$**

### Experimental Design and Results

We present a quantitative assessment of isotope effect expression of soil denitrification across a range of C and  $\text{NO}_3^-$  availabilities. This experiment tests the hypothesis that isotopic expression of soil denitrification (a kinetic process) increases with  $\text{NO}_3^-$  availability (reaction substrate) and decreases with increasing availability of organic C (electron donor). Periods of both net consumption and net production of nitrate were observed, yet only the net consumption events had significant isotope effects. Isotope effects ranged from 2–22‰. Isotopic enrichment increased with increasing C until a threshold of 10% soil organic C was reached, after which only a small isotope effect was observed. This indicates that C availability is a key driver of variability in the isotope effect of denitrification. Isotope effects measured in this study were less than those used in current models, suggesting that the global denitrification flux is underestimated [3].

[1] Galloway, Leach, Blecker, & Erisman (2013) *Phil. Trans. R. Soc.* **368**. [2] Houlton & Bai (2009) *PNAS* **106**, 713–16. [3] Bai, Houlton, & Wang (2012) *Biogeosciences* **9**, 3287–304.