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# Using the isotopic composition of N cycle compounds to test process descriptions in biogeochemical models

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The nitrogen (N) cycle of terrestrial ecosystems is a complex interplay of transformation processes such as N mineralization, nitrification, denitrification, plant uptake and microbial immobilization, with N appearing in many different chemical species. Depending on speciation, N can have ambiguous effects on the climate. For instance, nitrous oxide ($N_2O$) is an important greenhouse gas, contributing to global warming while N based aerosols can reflect solar radiation resulting in a cooling effect. Hence, modeling the fate of the various N species is important to understand effects of N on the environment and the Earths´ climate, but there is a lack of constraints on modelled N balances and N losses to the environment.

Recently, the isotopic composition of soil N ($^{15}N/^{14}N$) has been suggested as a benchmark for validation of N cycle models as it reflects long-term (decadal) N balances and N losses. In addition to soil N isotopic composition, $^{15}N$ abundances of ammonium ($NH_4^+$) and nitrate ($NO_3^-$) as well as the intramolecular isotopic composition of the $N_2O$ molecule, i.e., site preference (SP), can provide short term (daily to monthly) information on N transformations, e.g. the relative contributions of nitrification and denitrification.

In the presented study, the parameterization of N cycling simulated by a biogeochemical model, LandscapeDNDC, was assessed by implementation of the stable isotope model SIMONE and comparison of model results for N isotopic compositions of bulk soil, $NH_4^+$ and $NO_3^-$ as well as $N_2O$ SP for two intensively managed grassland sites in Switzerland with measurement data.

Due to the different soil properties, SP and its dynamics were distinctly different for the two sites. LandscapeDNDC was capable to reflect the effect of soil properties on SP, and successfully simulated the temporal dynamics. Deviations of modelled and measured SP revealed that LandscapeDNDC tends to overestimate nitrification derived $N_2O$ under dry conditions and to underestimate $N_2O$ reduction to $N_2$, the terminal step of denitrification. While modelled and measured $NO_3^-$ isotopic composition agreed well, modelled $NH_4^+$ isotopic composition was enriched in $^{15}N$ compared to measurements, suggesting partially quantitative nitrification in soil aggregates. Modelled soil $^{15}N/^{14}N$ profiles were also more enriched than measurements which might be due to a bias in the fertilizer isotopic composition as indicated by additional simulations.

Validation of biogeochemical N models with isotope data has the potential to identify model weaknesses and improve our capabilities to support model-based development of strategies reducing N losses to the environment.