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Using site specific N_2O isotopic measurements to improve the process based biogeochemical model LandscapeDNDC

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The nitrogen (N) cycle of terrestrial ecosystems is a complex interplay of N transformation processes, for instance N mineralization, nitrification, denitrification, plant uptake and microbial immobilization. The majority of these transformations are controlled by soil microbes and determine the rates of gaseous and leaching losses to the environment.

While unpolluted ecosystems are characterized by tight N cycling, i.e., minor gaseous and leaching losses, the excessive use of N fertilizers has amplified N release from terrestrial ecosystems, which is associated with adverse environmental effects. For instance, the surplus N in terrestrial ecosystems has increased soil nitrous oxide (N_2O) emissions, which contributes to stratospheric ozone depletion and global warming. Process-based biogeochemical models are increasingly used to develop targeted mitigation strategies aiming to reduce environmental impacts of fertilizer N losses while sustaining plant productivity. Although such models consider all relevant N cycling processes, including the different N_2O producing processes, they are usually calibrated and validated with total N_2O exchange rates. This approach leaves the different N_2O producing processes, i.e., nitrification and denitrification unconstrained.

As a consequence, the improvement and advanced validation of biogeochemical models requires information on the different N_2O producing processes. The isotopic quantity "site preference" (SP; difference of $\delta^{15}N$ of N_2O substituted with ^{15}N at the central and terminal position) is considered a powerful tool for partitioning N_2O emissions to nitrification and denitrification.

To further constrain the biogeochemical model LandscapeDNDC with novel (SP) and traditional ($\delta^{15}N$) isotopic measurements, we implemented a sub-model calculating the isotopic composition of the various N compounds based on processes represented by the ecosystem model LandscapeDNDC.

Here we show an assessment of the performance of the isotope sub-model based on a comparison of simulated and measured $\delta^{15}N$ and SP in soil emitted N_2O using datasets obtained during field campaigns in Switzerland and Germany (ScaleX 2016). The comparison of measured and modelled N_2O isotopic composition reveals potential for model improvement following fertilizer addition. In addition, we discuss the sensitivity of the model towards reported variability of fractionation factors, the influence of N_2O reduction on the N_2O isotopic composition and the influence of process rates and meteorological conditions on the simulated isotopic composition.