



Reconciling high-temporal-resolution field measurements of N₂O isotopic composition with a biogeochemical model revealed denitrification as the main N₂O source

Erkan Ibraim (1,2), Tobias Denk (3), Benjamin Wolf (3), Matti Barthel (2), Rainer Gasche (3), David Kraus (3), Wolfgang Wanek (4), Shasha Zhang (4), Ralf Kiese (3), Klaus Butterbach-Bahl (3), Sarah Eggleston (1), Lukas Emmenegger (1), Johan Six (2), and Joachim Mohn (1)

(1) Empa, Dübendorf, Switzerland (erkan.ibraim@empa.ch), (2) ETH-Zürich, Swiss Federal Institute of Technology, Department of Environmental Systems Science, CH-8092 Zürich, Switzerland, (3) Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research (IMK-IFU), D-82467 Garmisch-Partenkirchen, Germany, (4) University of Vienna, Department of Microbiology and Ecosystem Science, Division of Terrestrial Ecosystem research, A-1090 Vienna, Austria

Increased emissions from agricultural soils are the most important anthropogenic contribution to the elevated atmospheric abundance of N₂O, which is a potent greenhouse gas and the most important contributor to stratospheric ozone destruction. In soils, microorganisms predominately produce N₂O by nitrification and denitrification. Biogeochemical models simulate these processes and are increasingly used to assess N₂O mitigation strategies. However, the lack of field methods allowing the direct partitioning of N₂O to source processes entails a large uncertainty with regard to their relative contribution.

The intramolecular distribution of ¹⁵N in the N₂O molecule, also known as site preference, provides unique information to disentangle the relative contribution of nitrification and denitrification. On-line analysis of the changes in intramolecular N₂O isotopic composition in ambient air has been achieved recently, but this approach alone i) does not allow an explicit spatial allocation of the isotopic signature and ii) is limited to events with a strong increase in N₂O concentrations, which may obscure short term variations of the dominant N₂O producing processes, e.g. due to day-time temperature or radiation changes. To address these shortcomings, we combined laser spectroscopy based on-line analysis of the intramolecular N₂O isotopic composition [1] with the biogeochemical model LandcapeDNDC and SIMONE, a stable isotope model for nutrient cycles [2]. N₂O emissions were spatially allocated by coupling the laser spectrometer to automated static flux chambers, which also enabled higher sensitivities for periods with low N₂O fluxes and higher temporal resolution than previous studies [3, 4]. This approach allowed us assessing the relative contributions of nitrification and denitrification during a field campaign between August and December in 2017 on a grassland site close to Beromünster, Central Switzerland. Both N₂O isotope measurements and model results indicated continuous predominance of denitrification and hardly any temporal variability in N₂O SP. This finding was independent of the water content close to the soil surface, suggesting that N₂O production in the subsoil under high water filled pore space conditions outweighed the production of N₂O by nitrification closer to the surface. The modelled isotopic composition was offset by 1.9 ‰ with respect to the observed values. This indicates that the model parametrization reflects the dominant N₂O production pathway but slightly overestimates the contribution of denitrification. To our knowledge, this is the first observation-based application and validation of a biochemical soil model using N₂O isotopes. The application of this stable isotope based model validation approach at other sites and the comparison with other models will help to identify potential shortcomings and improve our capability to support N₂O mitigation strategies using real-time measurements of stable N₂O isotopes and corresponding soil chemistry and emission models.

References

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