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Isotopomer mapping approach to determine N₂O production pathways and N₂O reduction

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Stable isotopomer analyses of soil-emitted N₂O ($\delta^{15}\text{N}$, $\delta^{18}\text{O}$ and SP = ^{15}N site preference within the linear N₂O molecule) may help to distinguish N₂O production pathways and to quantify N₂O reduction to N₂. Different N₂O forming processes are characterised by distinct isotopic characteristics. Bacterial denitrification shows significantly lower SP and $\delta^{18}\text{O}$ values when compared to fungal denitrification and nitrification processes. But SP and $\delta^{18}\text{O}$ values are also altered during N₂O reduction to N₂, when the residual N₂O is enriched in ^{18}O and centrally located ^{15}N , resulting in increased $\delta^{18}\text{O}$ and SP values. Hence, the interpretation of these isotope characteristics is not straightforward, because higher $\delta^{18}\text{O}$ and SP values may be due to admixture of N₂O from fungal denitrification or nitrification, or due to N₂O reduction to N₂. One of these processes, either admixture or reduction, can be quite well quantified if the other one is determined with independent methods. But usually both processes are unknown and the ability to estimate both of them simultaneously would be very beneficial.

Here we present an attempt to determine both the admixture and the reduction simultaneously using the isotopomer mapping, i.e. the relation between $\delta^{18}\text{O}$ and SP. The measured sample points are typically situated between the two lines: reduction line with a typical slope of about 0.35 and mixing line with a higher slope of about 0.8. Combining the reduction and the mixing vector allows for the determination of both processes based on the location of the sample point between the lines.

We tested this new approach for laboratory incubation studies, where a reference method for N₂O reduction quantification was applied, i.e. ^{15}N gas flux method or incubations in He atmosphere. This allowed us to check how well the calculated amounts for N₂O reduction agree with the results provided by the reference method. The general trend was quite well reflected in our calculated results, however, quite often we deal with significant underestimation of N₂O reduction. This may be due to numerous sources of uncertainties, especially for the assumed slopes for mixing and reduction lines. The slope of the mixing line depends on the endmembers isotopic signatures which are represented by quite wide ranges of values. The slope of the reduction line depends on the isotope effects associated with N₂O reduction which also represent possible ranges of values.