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# Simultaneous determination of source processes and reduction of N2O using isotopocules – prerequisites and limitations

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Soil N2O fluxes originate from a multiple of mostly microbial processes where the currently known include production by nitrification (including hydroxylamine oxidation and nitrifier denitrification), fungal and bacterial denitrification, co-denitrification, DNRA as well as N2O reduction to N2 by bacterial denitrification. Better knowledge on their significance and control is needed to better predict gaseous N fluxes from soil. In recent years, stable isotope signatures of N2O such as $\delta$18O, average $\delta$15N ($\delta$15Nbulk) and 15N site preference (SP = difference in $\delta$15N between the central and peripheral N positions of the asymmetric N2O molecule) have been used to characterize N2O turnover processes including N2O production and reduction by microbial denitrification. While it is generally accepted that different microbial processes of N2O production are associated with specific isotope effects leading to characteristic "endmember" values of N2O produced, there is also consensus that a clear distinction and identification of processes contributing to N2O fluxes is hampered by several factors including the impact of N2O reduction and its (variable) isotope effect, variability of endmember values as well as isotopic values of N2O precursors and their spatial variability. This leads to substantial uncertainty in identification and quantification of different N2O processes, unless some of these factors can be estimated or excluded, which we will illustrate by Monte-Carlo modelling. Therefore, in order to obtain useful information from N2O isotopocules, it is necessary to constrain as many unknowns as possible. We will show examples how this can be done. Moreover, we will illustrate why $\delta$15Nbulk is currently a poor indicator for source processes due to the difficulty to determine $\delta$15N of the precursors of N2O. Finally, we show a comparison of N2O reduction in the field determined by the isotopocule approach and by the 15N gas flux method as independent reference method. We conclude that the isotopocule approach is principally a powerful tool to identify N2O processes that are difficult or impossible to determine otherwise, but to obtain meaningful results its prerequisites and limitations must be taken into account.