Nitrous oxide (N\textsubscript{2}O) is a potent greenhouse gas and the strongest ozone-destroying substance emitted this century. Reliable predictions of future emissions, requires knowledge of the responsible N\textsubscript{2}O source processes. Isotopic composition of N\textsubscript{2}O is a tracer to distinguish between different emission pathways, as well as constraining the stratospheric N\textsubscript{2}O sink. The four most abundant N\textsubscript{2}O isotopic species are: \textsuperscript{14}N\textsubscript{14}N\textsubscript{16}O (99%), \textsuperscript{14}N\textsuperscript{15}N\textsubscript{16}O (\textalpha, 0.4%), \textsuperscript{15}N\textsubscript{14}N\textsubscript{16}O (\textbeta, 0.4%) and \textsuperscript{14}N\textsubscript{14}N\textsubscript{18}O (0.2%). Due to its asymmetric molecular structure, N\textsubscript{2}O (\textalpha) and N\textsubscript{2}O (\textbeta) differ only in the position of the \textsuperscript{15}N atom, and the difference in their abundance – known as site preference (SP) – is a particularly powerful indicator for different N\textsubscript{2}O production mechanisms.

Here we illustrate the potential of laser spectroscopy for real-time, high-precision analysis of isotopic composition in ambient N\textsubscript{2}O. Furthermore, we present applications, in agricultural as well as suburban environments, illustrating the advantage and necessity of real-time data of trace gas isotope ratios. In an extensive campaign above a managed grassland, nitrifier-denitrification and denitrification were identified as prevalent sources of N\textsubscript{2}O and variations in isotopic composition were attributed to alterations in the extent to which N\textsubscript{2}O was reduced to N\textsubscript{2} \cite{wolf2015}. In an ongoing project, we validate the real-time N\textsubscript{2}O isotope data against a process-based biogeochemical soil model (DNDC) with an isotope sub-module (SIMONE), which is based on published isotope effects \cite{denk2017}. At a suburban site, the isotopic composition of atmospheric N\textsubscript{2}O was monitored over 18 months to determine the source isotopic composition, which varied significantly compared to chemical and meteorological parameters. FLEXPART-COSMO transport modelling in combination with modified EDGAR inventory emissions was able to capture variability in N\textsubscript{2}O mole fraction well, but simulations of isotopic composition showed little agreement with observations, indicating that the range of literature values of isotopic source signatures significantly underestimates the true variability \cite{harris2017}.

In summary, we are convinced that real-time analysis of N\textsubscript{2}O isotopic composition is an efficient approach to disentangle N\textsubscript{2}O source / sink processes in agricultural as well as suburban / industrial environments. Combination of point measurements with modelling approaches provides spatial resolution and enables validation of emission inventories.

References

\cite{wolf2015} B. Wolf et al., First on-line isotopic characterization of N\textsubscript{2}O above intensively managed grassland, Biogeosciences, 12, 2517–2531, 2015.
