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# Disentangling $N_2O$ emitting source processes with field-scale online measurements of the four most abundant $N_2O$ isotopocules

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Understanding and quantifying the biogeochemical cycle of $N_2O$ is essential to develop effective $N_2O$ emission mitigation strategies. We present a fully-automated measurement technique that allows simultaneous, high-precision quantification of the four main $N_2O$ isotopocules ($^{14}N^{14}N^{16}O$, $^{14}N^{15}N^{16}O$, $^{15}N^{14}N^{16}O$ and $^{14}N^{14}N^{18}O$) at ambient $N_2O$ abundances. The instrumentation consists of a trace gas extractor (TREX) coupled to a quantum cascade laser absorption spectrometer (QCLAS), designed for autonomous operation at remote measurement sites. All system components have been integrated into a standardized instrument rack to improve portability and accessibility for maintenance. With an average sampling frequency of approximately 1 $hr^{-1}$, this instrumentation achieves a repeatability of 0.09, 0.13, 0.17 and 0.12 ‰ for $\delta^{15}N^{\alpha}$, $\delta^{15}N^{\beta}$, $\delta^{18}O$ and site preference of $N_2O$ in ambient air, respectively [1]. The repeatability for $N_2O$ mole fraction measurements is better than 1 ppb (parts per billion, $10^{-9}$ moles per mole of dry air).

This TREX-QCLAS technique was deployed in two field campaigns. In 2016 within the ScaleX campaign at the TERENO site Fendt in Germany and in 2017 in the catchment of the Beromünster tall tower in Central Switzerland. Isotopic signatures of the emitted $N_2O$ were interpreted in relation to management events and meteorological conditions to shed light into different $N_2O$ source processes. Our preliminary results confirm previous incubation studies that nitrification was the predominating $N_2O$ emitting process under dry and warm conditions. Also in accordance with previous studies on smaller scales is our finding that denitrification was occurring under wet conditions, and quantitatively contributing the major part of $N_2O$ emissions. As a next step, $N_2O$ isotopic measurement results will be evaluated in conjunction with $\delta^{15}N$ values of $N_2O$ precursors ($NH_4^+$, $NO_3^-$). Finally, results will be discussed in relation to a biogeochemical soil model (L-DNDC) with an isotope sub-module (SIMONE) developed at IMK-IFU [2].

[1] E. Ibraim et al. (2017) Isotopes in Environmental and Health Studies, doi: 10.1080/10256016.2017.1345902.

[2] T. Denk et al. (2017) Soil Biology & Biochemistry, doi: 10.1016/j.soilbio.2016.11.015.