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Elucidating source processes of N2O fluxes following grassland-to-field-conversion using isotopologue signatures of soil-emitted N2O

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Conversion of grassland to arable land often causes enhanced nitrous oxide (N2O) emissions to the atmosphere. This is due to the tillage of the sward and subsequent decomposition of organic matter. Prediction of such effects is uncertain so far because emissions may differ depending on site and soil conditions. The processes of N2O turnover (nitrification, production by bacterial or fungal denitrifiers, bacterial reduction to N2) are difficult to identify, however. Isotopologue signatures of N2O such as δ18O, average δ15N (δ15Nbulk) and 15N site preference (SP = difference in δ15N between the central and peripheral N positions of the asymmetric N2O molecule) can be used to characterize N2O turnover processes using the known ranges of isotope effects of the various N2O pathways.

We aim to evaluate the impact of grassland-to-field-conversion on N2O fluxes and the governing processes using isotopic signatures of emitted N2O.

At two sites, in Kleve (North Rhine-Westphalia, Germany, conventional farming) and Trenthorst (Schleswig-Holstein, Germany, organic farming), a four times replicated plot experiment with (i) mechanical conversion (ploughing, maize), (ii) chemical conversion (broadband herbicide, maize per direct seed) and (iii) continuous grassland as reference was started in April 2010. In Trenthorst we additionally established a (iv) field with continuous maize cultivation as further reference. Over a period of two years, mineral nitrogen (Nmin) content was measured weekly on soil samples taken from 0-10 cm and 10-30 cm depth. Soil water content and N2O emissions were measured weekly as well. Gas samples were collected using a closed chamber system. Isotope ratio mass spectrometry was carried out on gas samples from selected high flux events to determine δ18O, δ15Nbulk and SP of N2O.

δ18O and SP of N2O exhibited a relatively large range (32 to 72 ‰ and 6 to 34 ‰ respectively) indicating highly variable process dynamics. The data-set is grouped according to conditions favouring nitrification (low soil water content, high NH4-N content) or denitrification (high soil water content, high NO_3-N content, high availability of organic C after tillage of the sward). Isotopologue patterns are compared to known isotope effects of possible turnover processes. This is to verify if the data-set is promising to further constrain N2O processes by process-based isotope fractionation modelling.