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Elucidating soil pore N_2O production and consumption processes using isotope and microbial gene analysis: A depth profile approach

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N_2O is a stratospheric ozone depleting substance and a potent greenhouse gas which significantly contributes to global warming. Although soils are the largest source of N_2O emissions, knowledge gaps in the understanding of N_2O production and reduction processes in soils still exist. Here, we investigated N_2O production and consumption processes along soil depth profiles in a mesocosm experiment using natural-abundance N_2O and NO_3^- isotopic signatures as well as abundances of soil microbial genes associated with N_2O production (*nirK, nirS*) and reduction (*nosZ*). Soil columns either displayed undisturbed soil stratification (control treatments), or contained an artificial clay layer at 35 cm depth (clay treatment), which acted as a diffusion barrier and thus induced O_2-limited conditions in deeper strata. We collected soil pore gas, soil solution and soil samples at five depths of the soil columns over the course of four weeks. In addition, we continuously monitored N_2O fluxes at the soil surface and soil environmental parameters (oxygen, moisture, temperature) along the soil depth profiles. Microbial gene analysis in soil samples revealed similar abundances of *nirK*, *nirS* and *nosZ* in the two treatments across the entire soil depth profiles. The distribution of the functional genes was thus not indicative of enhanced N_2O production and/or reduction in O_2-limited conditions. However, lowest O_2 concentrations below the clay layer were associated with highest ^{15}N and ^{18}O enrichments in both NO_3^- and N_2O, indicating N_2O production by denitrification and fractional N_2O reduction. In addition, we found higher N_2O concentrations and surface fluxes for the clay treatment. Our observations imply a dominance of N_2O production over N_2O reduction, even under conditions most favorable for complete denitrification.