Spatial and temporal variability of nitrous oxide fluxes in a German crop rotation

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Abstract

Nitrous oxide (N_2O) fluxes exhibit a high temporal and spatial variability, challenging their accurate quantification. Combining N_2O flux measurements from static chambers and eddy covariance (EC) towers could lead to an improved characterization of the variability of fluxes while providing insights on their underlying drivers.

Since 2022, we monitor N_2O fluxes with an EC-tower in an agricultural field in central Germany. During 2023-2024, we also measure the fluxes with manually-operated static chambers at eight sampling points within the EC-tower footprint. To better understand the spatial variability of the fluxes, we additionally measure 100 points in a 20x20 m grid with a chamber and a portable N_2O analyzer, following fertilization or incorporation of residues after harvest. The crop rotation during the study period was barley - white mustard - sugar beet - winter wheat. To further explore the drivers for N_2O fluxes, mineral nitrogen, dissolved organic carbon and soil water content, were regularly measured in the topsoil.

During the sugar beet cultivation 2023, we observed that soil properties explained the temporal, but not the spatial variability of N_2O fluxes. Measurements of the 100 points exhibited a large variability, with fluxes ranging from -20 to 83 µg N_2O-N m^{-2} h^{-1}. EC- and chamber-based N_2O fluxes were comparable, but some of the emission peaks captured by the EC-tower were missed with the chambers. EC-based N_2O fluxes were highest after rainfall events in late June 2023 and this 10-day-period accounted for ~50% of the annual N_2O budget. In contrast, post- fertilization emissions were negligible for the annual budget.