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Drivers of small scale variability in soil-atmosphere fluxes of CH4, N2O and CO_2 in a forest soil

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Soil-atmosphere fluxes of CH4, N2O and CO_2 can vary on different spatial scales, on large scales between ecosystems but also within apparently homogenous sites. While CO_2 and CH4 consumption is rather evenly distibuted in well aerated soils, the production of N2O and CH4 seems to occur at hot spots that can be associated with anoxic or suboxic conditions. Small-scale variability in soil properties is well-known from field soil assesment, affecting also soil aeration and thus theoretically, greenhouse gas fluxes. In many cases different plant species are associated with different soil conditions and vegetation mapping should therefor combined with soil mapping.
Our research objective was explaining the small scale variability of greenhouse gas fluxes in an apparently homogeneous 50 years old Scots Pine stand in a former riparian flood plain.We combined greenhouse gas measurements and soil physical lab measurments with field soil assessment and vegetation mapping. Measurements were conducted with at 60 points at a plot of 30 X 30 m at the Hartheim monitoring site (SW Germany). For greenhouse gas measurements a non-steady state chamber system and laser analyser, and a photoacoustic analyser were used.
Our study shows that the well aerated site was a substantial sink for atmospheric CH4 (-2.4 nmol/m^2 s) and also a for N2O (-0.4 nmol/m^2 s), but less pronounced, whereas CO_2 production was a magnitude larger (2.6 μmol/m^2 s). The spatial variability of the CH4 consumption of the soils could be explained by the variability of the soil gas diffusivity (measured in situ + using soil cores). Deviations of this clear trend were only observed at points where decomposing woody debris was directly under the litter layer. Soil texture ranged from gravel, coarse sand, fine sand to pure silt, with coarser texture having higher soil gas diffusivity. Changes in texture were rather abrupt at some positions or gradual at other positions, and were well reflected in the vegetation structure. On patches of gravel and coarse sand there was hardly any ground vegatation, and a shrublayer was found only at silty patches
Our results indicate that a stratification and regionalisation approach based on vegetation structure and soil texture represents a promising tool for the adjustment of sampling designs for soil gas flux measurement.

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