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# Fluxes of $CO_2$, CH4 and N2O at two European beech forests: linking soil gas production profiles with soil and stem fluxes

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Soil and plant surfaces are known to exchange greenhouse gases with the atmosphere. Some gases like nitrous oxide (N2O) and methane (CH4) can be produced and re-consumed in different soil depths and soil compartments, so that elevated concentrations of CH4 or N2O in the soil do not necessarily mean a net efflux from the soil into the atmosphere. Soil aeration, and thus the oxygen status can underlay a large spatial variability within the soil on the plot and profile scale, but also within soil aggregates. Thus, conditions suitable for production and consumption of CH4 and N2O can vary on different scales in the soil. Plant surfaces can also emit or take up CH4 and N2O, and these fluxes can significantly contribute to the net ecosystem exchange. Since roots usually have large intercellular spaces or aerenchyma they may represent preferential transport ways for soil gases, linking possibly elevated soil gas concentrations in the subsoil in a "shortcut" to the atmosphere.

We tested the hypothesis that the spatial variability of the soil-atmosphere fluxes of $CO_2$, CH4 and N2O is caused by the heterogeneity in soil properties. Therefore, we measured soil-atmosphere gas fluxes, soil gas concentrations and soil diffusivity profiles and did a small scale field assessment of soil profiles on the measurments plots. We further tried to link vertical profiles of soil gas concentrations and diffusivity to derive the production and consumption profiles, and to link these profiles to the stem-atmosphere flux rates of individual trees.

Measurements were conducted in two mountain beech forests with different geographical and climatic conditions (White Carpathians, Czech Republic; Black Forest, Germany). Gas fluxes at stem and soil levels were measured simultaneously using static chamber systems and chromatographic and continuous laser analyses. Monitoring simultaneously vertical soil gas profiles allowed to assess the within-soil gas fluxes, and thus to localize the production and consumption sites of soil gases in the adjacent soil.

Soils at both sites took up CH4 and N2O and emitted $CO_2$. Soil gas profiles at the Black Forest showed only CH4 and N2O consumption. CH4 uptake was much larger by the well aerated Black Forest soil than by the loamy-clay soil in the White Carpathians. Here, it was possible to stratify the apparently homogenous site into two plots, one having redoximorphic features in the soil profiles, the other plot without. It seemed that CH4 and N2O were mainly produced in the deeper soil at the plot with temporarily reducing conditions. Beech stems mostly took up N2O from the atmosphere at both sites, whereas CH4 was emitted. The stem CH4 flux was higher for the White Carpathians than for the Black Forest site. Thus, the tree and soil flux of CH4 seems to be affected by soil structure, soil water content and the redox potential in the rooting space. We conclude from our results that trees might provide preferential pathways for greenhouse gases produced in the subsoil thereby enhancing the release of greenhouse gases.

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