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Tracing changes in soil N transformations to explain the doubling of N2O emissions under elevated CO_2 in the Giessen FACE

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To reduce the emissions of greenhouse gases (CO_2, CH4 & N2O) it is important to quantify main sources and identify the respective ecosystem processes. While the main sources of N2O emissions in agro-ecosystems under current conditions are well known, the influence of a projected higher level of CO_2 on the main ecosystem processes responsible for N2O emissions has not been investigated in detail. A major result of the Giessen FACE in a managed temperate grassland was that a +20% CO_2 level caused a positive feedback due to increased emissions of N2O to 221% related to control condition. To be able to trace the sources of additional N2O emissions a 15N tracing study was conducted. We measured the N2O emission and its 15N signature, together with the 15N signature of soil and plant samples. The results were analyzed using a 15N tracing model which quantified the main changes in N transformation rates under elevated CO_2.
Directly after 15N fertilizer application a much higher dynamic of N transformations was observed than in the long run. Absolute mineralisation and DNRA rates were lower under elevated CO_2 in the short term but higher in the long term. During the one year study period beginning with the 15N labelling a 1.8-fold increase of N2O emissions occurred under elevated CO_2. The source of increased N2O was associated with NO_3- in the first weeks after 15N application. Elevated CO_2 affected denitrification rates, which resulted in increased N2O emissions due to a change of gene transcription rates (nosZ/(nirK+nirS)) and resulting enzyme activity (see: Brenzinger et al.).
Here we show that the reported enhanced N2O emissions for the first 8 FACE years do prevail even in the long-term (> 15 years). The effect of elevated CO_2 on N2O production/emission can be explained by altered activity ratios within a stable microbial community.