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Positive feedback of future atmospheric CO_2 concentrations on N_2O emissions: Results from a 9-year FACE experiment

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To evaluate climate forcing under increasing atmospheric CO_2 concentrations, feedback effects on greenhouse gases such as nitrous oxide (N_2O) with a high global warming potential should be taken into account. N_2O is produced in soils via aerobic nitrification or anaerobic denitrification. Few experiments investigated a possible feedback, most of them short-term or in greenhouses (Ineson et al. 1998; Kettunen et al. 2006). So far, literature suggests that a feedback of elevated CO_2 via plants on N_2O emissions will be a minor problem in the future since a moderately positive response was mainly found in intensively N-fertilized ecosystems with denitrification as the dominant N_2O-producing process (e.g. Baggs et al. 2003).

Our results, however, challenge this comforting perception, based on more than 9 years of continuous N_2O flux measurements in a Free Air Carbon dioxide Enrichment (FACE) study on old, N-limited temperate grassland. Over the entire experimental period (May 1998 – Dec. 2007), N_2O emissions doubled significantly under elevated CO_2 (228%; 0.84 vs. 1.92 kg N_2O-N ha^{-1} y^{-1}). The strongest stimulation repeatedly occurred during the vegetative-growth period at background, low soil mineral-N concentrations, indicating that the positive feedback cannot easily be mitigated by reducing the N fertilization.

Averaged over the entire FACE experiment, the additional N_2O emissions caused by elevated CO_2 equalled 4885 kg CO_2-equivalents ha^{-1}, i.e. 505 kg CO_2 ha^{-1} have

to be sequestered annually to counterbalance the CO_2-induced N_2O emissions. However, a concomitant soil C-sequestration did not occur in the FACE experiment. On the contrary, the soils lost organic carbon under both CO_2 treatments, which was neither prevented nor mitigated by elevated CO_2. In addition, we observed significantly higher dark ecosystem respiration rates under elevated CO_2 (+13%, 9-yr-mean). Hence, without considerably increasing soil C sequestration under rising atmospheric CO_2 concentrations, temperate grasslands may become GHG sources in the near future largely by a positive feedback on N_2O emissions.

References:

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