Scientific Summary

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Modelling of nitrous oxide emissions from clover grass ley – wheat crop rotations in central eastern Germany An application of DNDC

Nitrous oxide (N_2O) is one of the three primary anthropogenic greenhouse gases. The agricultural sector accounts for 75.7 % of all anthropogenic N_2O emissions in Germany (Umweltbundesamt, 2012). Thus, accurately estimating N_2O emissions as well as mitigation strategies for N_2O are crucial.

This study optimizes the process-based model DNDC to simulate N_2O emissions by conventional winter wheat and three different organic clover grass ley – wheat rotations at a site in central eastern Germany (Bad Lauchstädt: 51°24' N, 11°53' E). The model simulates the soil environment (temperature, moisture, oxygen content etc.), plant growth and decomposition to determine nitrification, denitrification as well as fermentation. The central focus of this study is to assess the ability of DNDC to simulate N_2O emissions in Bad Lauchstädt, followed by a comparison of the different crop rotations with respect to their N_2O emissions based on weekly measurements and DNDC simulations. The study concludes with an investigation of emissions under future climate conditions.

DNDC is able to reproduce monthly patterns of emissions in Bad Lauchstädt. Underlying processes such as plant growth and soil moisture are not represented with sufficient precision. The mean modelling efficiency (Nash Sutcliff Efficiency) of the validation runs for the monthly N_2O fluxes is 0.136 and ranges from -0.526 to 0.446. Predicted daily and annual fluxes show a great offset compared to measured values. Emissions in Bad Lauchstädt are very low if compared to other observations in Germany and are primarily constrained by soil moisture and not by nitrogen availability. Neither the measurements nor the modelling results are able to resolve significant differences between the four crop rotations. According to the measurements, conventional winter wheat emits 836 g N ha^{-1} a^{-1}, while the organic treatments release between 645 g N ha^{-1} a^{-1} and 1044 g N ha^{-1} a^{-1}. DNDC simulates no significant change of N_2O emissions under future climate conditions; this finding is not robust due to the abovementioned drawbacks of DNDC in this study.

Improved estimates could be obtained by adjusting the ability of DNDC to capture the situation in Germany and in Bad Lauchstädt. Special attention should be given to the implementation of plant growth and evapotranspiration. Better comparison of treatments requires a longer measurement period and a higher temporal resolution, so that duration and height of peak emission events can be captured.

Keywords: Physical Geography and Ecosystem analysis, DNDC, N_2O, Bad Lauchstädt, clover grass ley, winter wheat, spring wheat, climate change, emission factors

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