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Modelling nitrous oxide emissions from agricultural soil incubation experiments using CoupModel

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To develop good mitigation strategies, estimates of nitrous oxide (N_2O) emissions from agricultural soils are needed. Process-based biogeochemical models have been used for such estimation but those have mainly been tested on field scaled measurement. Here we will explore how experimentally laboratory measurements can be used to to improve future model use. Based on a series of 43 days incubation experiments and a process model (CoupModel), we assessed the model's sensitivity and uncertainty in estimating N_2O fluxes, CO_2 fluxes and soil mineral N. Our results suggested that the most sensitive parameters to N_2O flux estimates were related to the decomposibility of soil organic matter and related links to the denitrification processes. The model showed better performance in simulating low-magnitude daily and cumulative N_2O fluxes but a tendency to underestimate the fluxes as observed values increased. Residual analysis indicated that nitrification rate could be underestimated but did not sufficiently explain the model deviations. We also evaluated ancillary variables regarding N cycling, which indicates that additional types of observed data including soil oxygen concentrations and the sources of emitted N_2O, are required to evaluate model performance and possible biases. The modeled response to abiotic factors (e.g. soil moisture) did not reflect the measured values using consistent parameter sets, limiting the model application under constantly changing environmental conditions in reality. To conclude, the restricted description of N cycling process in the model may not be able to consistently simulate the denitrification and nitrification processes behind N_2O emissions and limits the extension of models beyond calibration. This calls for more frequent and more aspects of measurements in future experimental design for model evaluation and development. For the development of process models including CoupModel, there is a need to address crucial missing processes including solute diffusion and microscale heterogeneity, revisit current subrountines of moisture response functions and denitrifier growth dynamics, and report more aspects of simulated outputs for prediction and model.