Assessment of uncertainties in nitrogen and greenhouse gas fluxes from agro-ecosystems in Europe

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Overview

To assess the responses of nitrogen (N) and greenhouse gas (GHG) emissions to pan-European changes in land cover, land management and climate an integrated dynamic model, INTEGRATOR, has been developed. This model includes both simple process-based descriptions and empirical relationships, and uses detailed GIS-based environmental data and farming data in combination with various downscaling methods. INTEGRATOR assesses N and GHG fluxes at the level of about 40 000 homogeneous combinations of soil characteristics, topography and climate, so called NitroEurope Calculation Units (NCU). This paper analyses the propagation of uncertainties in model inputs and model parameters to model outputs, using a Monte Carlo analysis. Uncertain model inputs and parameters were represented by probability distributions, while accounting for spatial correlation. At EU-27 level, calculated uncertainties for N leaching to groundwater and N_2 emissions are twice as high (errors ranging from 15 to 20 %), as for the emission of N_2O, NH_3 and CH_4 (errors ranging from 10 to 12 %).

Methods/Approach

INTEGRATOR (De Vries et al., 2011) has multiple outputs whose levels of uncertainty may be different. Moreover, the contribution of individual uncertainty sources to the output uncertainty may differ between model outputs. The uncertainty propagation was analysed for N_2O, NH_3, N_2 and CH_4 emissions and N leaching from agriculture for the entire EU27 and for individual countries. The investigated uncertainties in model input data comprise groups of parameters related to animal numbers, livestock excretion, housing emissions, N inputs by mineral fertilizer, crop residues, fixation and deposition, crop N uptake, soil emission factors and leaching fractions. Uncertainties in categorical data such as land use maps and soil type maps were not included in the analysis. A crucial aspect is to include spatial correlation between model parameters, otherwise the uncertainty assigned independently to each NCU would disappear completely at the European scale. Rather than using a common geostatistical procedure based on semi-variograms, we included the spatial correlation in a pragmatic way following an approach by Lesschen et al. (2007). Therefore we distinguish four scale levels: NCU (the smallest), NUTS2/3, country and Europe (EU-27). The degree of spatial correlation is defined as a correlation between parameters in different (i) NCUs within the same NUTS2/3 region, (ii) NUTS2/3 regions within the same country, (iii) countries within the EU-27. The probability distributions and spatial correlations that characterise the uncertainties in model inputs and parameters were partly derived by using expert judgement and partly from European datasets. In total more than 50 model inputs and parameters were included in the analyses, for which we performed 1000 Monte Carlo runs.

Results

Results show large uncertainties for N leaching to groundwater and N_2 emissions (relative errors ranging from 15 to 20 % for EU-27 as a whole), and smaller uncertainties for the emission of N_2O, NH_3 and CH_4 (relative errors ranging from 10 to 12 %) (Fig. 1a). Uncertainties for EU-27 as a whole were much smaller compared to uncertainties at country level, since uncertainties and spatial variation in model outputs cancel partly out as a result of spatial aggregation. Uncertainty in the direct N_2O emission was mainly caused by uncertainty in N inputs, housing emission and crop uptake parameters, whereas uncertainty in indirect N_2O emission and N leaching was mainly caused by uncertainty in N inputs, crop uptake and N leaching parameters. For NH_3 emissions the largest uncertainties originated from the excretion parameters (Fig. 1b). For CH_4 the uncertainty was completely determined by the excretion parameters, since we only include enteric fermentation.

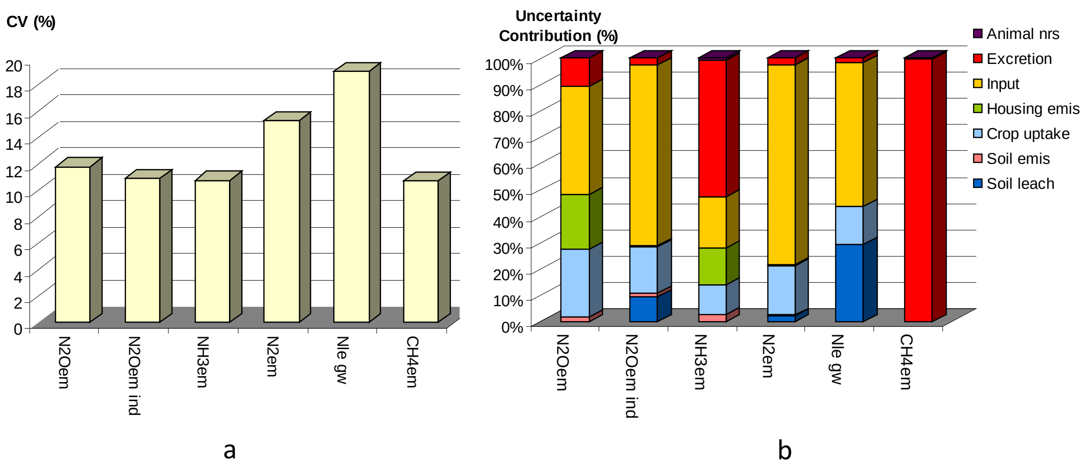

Fig. 1. Relative uncertainty (CV in %) in N_2O emission, NH_3 emission, N_2 emission, N leaching to groundwater and CH_4 emission (a), and uncertainty contributions of individual parameter groups (CV in %) to various model outputs for the EU-27 for the year 2000.

In conclusion this study shows large variation in uncertainty and uncertainty contribution of the different error sources across the various model outputs. Furthermore, the uncertainty in nitrogen and greenhouse gas fluxes differ per country.

References

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