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Parameter-induced uncertainty quantification of a regional N_2O and NO_3 inventory using the biogeochemical model LandscapeDNDC

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Numerical simulation models are increasingly used to estimate greenhouse gas emissions at site to regional and national scales and are outlined as the most advanced methodology (Tier 3) for national emission inventory in the framework of UNFCCC reporting. Process-based models incorporate the major processes of the carbon and nitrogen cycle of terrestrial ecosystems like arable land and grasslands and are thus thought to be widely applicable at various spatial and temporal scales. The high complexity of ecosystem processes mirrored by such models requires a large number of model parameters. Many of those parameters are lumped parameters describing simultaneously the effect of environmental drivers on e.g. microbial community activity and individual processes. Thus, the precise quantification of true parameter states is often difficult or even impossible. As a result model uncertainty is not solely originating from input uncertainty but also subject to parameter-induced uncertainty.
In this study we quantify regional parameter-induced model uncertainty on nitrous oxide (N_2O) emissions and nitrate (NO_3) leaching from arable soils of Saxony (Germany) using the biogeochemical model LandscapeDNDC. For this we calculate a regional inventory using a joint parameter distribution for key parameters describing microbial C and N turnover processes as obtained by a Bayesian calibration study. We representatively sampled 400 different parameter vectors from the discrete joint parameter distribution comprising approximately 400,000 parameter combinations and used these to calculate 400 individual realizations of the regional inventory. The spatial domain (represented by 4042 polygons) is set up with spatially explicit soil and climate information and a region-typical 3-year crop rotation consisting of winter wheat, rape- seed, and winter barley.
Average N_2O emission from arable soils in the state of Saxony across all 400 realizations was 1.43 $\pm$ 1.25 [kg N / ha] with a median value of 1.05 [kg N / ha]. Using the default IPCC emission factor approach (Tier 1) for direct emissions reveal a higher average N_2O emission of 1.51 [kg N / ha] due to fertilizer use. In the regional uncertainty quantification the 20% likelihood range for N_2O emissions is 0.79 – 1.37 [kg N / ha] (50% likelihood: 0.46 – 2.05 [kg N / ha]; 90% likelihood: 0.11 – 4.03 [kg N / ha]). Respective quantities were calculated for nitrate leaching.
The method has proven its applicability to quantify parameter-induced uncertainty of simulated regional greenhouse gas emission and nitrate leaching inventories using process based biogeochemical models.