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Effect of measurement network densities and stratification on the uncertainty of implied emission factors for national N2O budgets from agricultural mineral soils

Rene Dechow and Soeren Gebbert
Johann Heinrich von Thünen-Institute, Institute for Agricultural Climate Research, Bundesallee 50, 38116 Braunschweig

Among other GHG sources that are reported under the United Nations Framework Convention on Climate Change (UNFCCC) national budgets of nitrous oxide emissions from agricultural soils are often characterized by the highest estimation uncertainties within the sectors "agriculture" and "land use and land use change". The majority of recent national emission inventories in Europe are based on Tier 1 approaches. Nitrous oxide emissions from mineral soils are highly influenced by anthropogenic and environmental conditions like soil properties and climate. Specification of those controlling factors on a national to regional scale can highly influence the spatial emission pattern and might cause systematic errors when using Tier 1 emission factors.
Regionally stratified emission factors reflecting conditions that determine the N2O flux rates from agricultural soils could significantly improve the accuracy of national nitrous oxide emission inventories (Tier 2). If these stratified emission factors are based on measurement networks the density and stratification of measurement networks with respect to spatial variability of soil properties and climate is an important driver of emission factor uncertainty.
In the last two decades, intensive effort has been spend on the experimentally determination of nitrous oxide emissions at plot scale and related drivers resulting in numerous published data sets that were collected and analyzed within meta-studies and European and international projects. We give an overview on recently available data on direct nitrous oxide emissions on agricultural land in Europe. Mixed linear models are trained on these data sets. These models estimate N2O emissions in response to management, meteorological data and soil properties. Based on the developed mixed linear models the effect of N2O measurement network density and stratification on bias and uncertainty of national implied emission factors from agricultural soils are quantified by Monte Carlo analyses for 4 European countries.
Model results show that croplands and grasslands differ with respect to the effect of environmental conditions and management on N2O emissions, which requires specific measurement network designs for these agro-ecosystems. With regard to croplands the signal of nitrous oxide fluxes on nitrogen fertilization is strongly driven by environmental conditions. Measurement networks to improve N2O emission factors of croplands should focus on representing the spatial variability of key drivers like seasonal temperature, precipitation and soil texture. In terms of N2O emissions from croplands requirements on measurement network densities necessary to derive implied emission factors within an uncertainty of $\pm$ 20% are in most cases not met by recently available data on national level.
Nitrous oxide emissions of grasslands show a relative consistent nonlinear response on nitrogen fertilization. Besides representing environmental conditions, measurement networks to derive regional emission factors for grassland soils should focus on covering the range of possible nitrogen fertilization rates, which are often higher than on croplands, especially in regions with high livestock densities.