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Responses of direct N2O emissions from agricultural mineral soils on natural conditions and management – a multi site analysis across Europe

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Widely used approaches that relate direct N2O emissions to inputs of reactive N using globally estimated emission factors are believed to be highly uncertain and regionally biased because they do not account for effects of natural conditions on microbial mediated processes responsible for N2O production/consumption and N2O transport processes in soils. At the other side the development of process based approaches is suffering from the fact that sufficient data to feed and train these models is available for a limited number of sites only challenging the spatial representativeness of these approaches. Inventories and mitigation assessment deserve simple applicable tools with restricted data needs that describe major mechanisms or dependencies.

Last decades efforts in measuring direct annual and seasonal N2O emissions on plot scale built up data sets covering wide ranges of environmental conditions and management options. Statistical and hybrid approaches (fuzzy inference scheme) were used to infer responses of direct annual and seasonal N2O emissions on natural and anthropogenic drivers from multi-site measurements.

The underlying idea of inference schemes is to split the multidimensional response surface by rules into situations (sub domains) that produce a uniform N2O response. Factors lowering the unexplained variability of seasonal and annual N2O emissions were determined by a forward selection algorithm. Simulated annealing was used to train models.

For modeling of seasonal N2O emissions the input of the fuzzy inference scheme was generated by simple process based approaches (WFPS, soil temperature, available N).

Nitrous oxide emissions of cropland soils and grassland soils exhibited distinct emission patterns. On cropland soils significant amounts of N2O emit during autumn to spring and freeze thaw induced emission peaks highly impact the annual N2O budget. The strength of emission peaks throughout the year is driven by available N, SOC and WFPS. From this it follows that mitigation options targeting to decrease or inhibit denitrification and nitrification shortly after fertilization events will have a limited impact on annual emissions on croplands exposed to freeze thaw events. Increasing the N use efficiency over the year would be the most promising way to mitigate N2O emissions on cropland soils.

In contrast, on grassland N2O emission peaks in response to precipitation events and fertilisation dominated annual N2O emissions. Magnitude of emission peaks on combined effects of fertilizer application and precipitation follows a gradient from continental to temperate climate whereas WFPS (both, measured and modeled) and soil properties had less explanatory power. Managing nitrification and denitrification in the growing period could be sufficient to minimize annual N2O emissions on grasslands.

The developed response curves allow the estimation of spatially differentiated seasonal N2O emissions on management options regarding amount and timing of available N from fertilization and crop residues.