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Nitrogen-transformation processes under conditions of climate-induced drought and heavy rain from agricultural soils in the Pannonian area

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IPCC models predict increasing drought periods and heavy rain falls in the Pannonian area in Austria. However, there is a lack of understanding of how altered precipitation and thus soil moisture regime affect changes in N gas fluxes and underlying processes. The objective of the present study was, therefore, to determine the effects of climate-induced droughts and heavy rain on N gas fluxes (NO, N2O and N2) and to identify potential drivers.

For this purpose, the NO and N2O fluxes from three soils typical of the Pannonian area was determined regularly in a field trial with controlled irrigation from April 2014 to November 2016. The field trial is located at the lysimeter facility Hirschstetten, Vienna, Austria, which consists of 18 backfilled gravitation lysimeters (six replicates per soil type). Three replicates of each soil type (calcic chernozem, calcaric phaeozem and gleyic phaeozem) were watered according to the precipitation pattern predicted for the period from 2071 to 2100 simulating drought periods and heavy rain events (variant "prog.rain"). The remaining nine lysimeters (control; variant "curr.rain") were irrigated with respect to the 30 year mean of rainfall (amount and distribution) in Großenzersdorf, Marchfeld, Austria. To identify potential drivers of N gas fluxes in the soils investigated soil samples were taken at least four times per year and analyzed for important chemical (pH, NH4+ and NO_3- concentrations) and microbiological properties (e.g. microbial biomass C and N). Emissions of N2 were determined in the lab using the gas flow soil core technique. Additionally, a short-term lab experiment was carried out to investigate N gas fluxes (NO and N2O) after fertilization (calcium ammonium nitrate) in greater detail. Process based modelling was applied amongst others to study the impact of climate change on NO_3 leaching of the Pannonian area.

Flux rates of NO showed no marked fluctuations in the course of the year. More important than variations in the environmental conditions was fertilization. Fluxes of NO were independent of the precipitation pattern applied. There was a trend to higher mean N2O emissions from the "prog.rain" treatment compared to the control. In the short-term lab experiment, fertilization markedly increased NO release from all soils and both precipitation treatments. For all three soils, the increase in NO fluxes was more pronounced for the control than for the "prog.rain" treated samples, but N2O fluxes after fertilization from the "prog.rain" variant usually exceeded those from the "curr.rain" treatment. No differences in N2 emissions between the two precipitation treatments were detected. Mean NH4+ and NO_3- concentrations were not affected by precipitation treatment. Fluxes of N2O were not correlated with NO_3- concentrations. The impact assessment of climate change projections for the study region revealed an increase in NO_3- losses of 30 % (comparing 2050 with 2000).

The results suggest that altered precipitation patterns may affect N transformation processes such as denitrification. The impact assessment of climate change projections for the study region revealed an increase in NO_3 losses which will likely exceed the nitrate thresholds in the catchment.