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Dinitrogen emissions as an overlooked key component of the N balance of montane grasslands

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Numerous studies have been conducted on the emission dynamics and annual budget of the atmospheric pollutants and primary or secondary greenhouse gases NO_x, NH3 and N2O, i.e. gaseous N losses which can play an important role in the N budget of ecosystems. Due to still existing methodical problems in their quantification, considerably less is known on soil dinitrogen (N2) emissions, an inert gas with no hazardous effects on the environment. Understanding of soil N2 emissions however may be important to better understand and manage the N balance of ecosystems and also to mitigate the emissions of the precursor and potent greenhouse gas N2O.
Here we quantified soil N2 emissions from montane grasslands used for dairy farming as affected by climate change simulation (reduced annual precipitation, increased temperature). For this purpose, plant-soil-mesocosms were brought from field sites of different elevation to the laboratory for direct simultaneous quantification of soil N2 and N2O emissions by use of the Helium soil core method. Immediately after the measurements, the plant-soil mesocosms were reburied at the sites. Using this approach we found that under current climate conditions, soil N2 emissions exceeded soil N2O emissions by several orders of magnitude and increased from 25 kg N ha-1 year-1 (present climate) to 50 kg N ha-1 year-1 (climate change treatment). Because this approach based on monthly sampling cannot accurately consider N gas emission peaks after manure fertilization, measurements were supplemented by a laboratory incubation approach. In this experiment, the response of all N gas emissions (NH3, NO, N2O, N2) to manure fertilization (50 kg N ha-1) was monitored with subdaily temporal resolution until emissions had diminished. Total N gas losses amounted to roughly half of the supplied N by manure application. Surprisingly, we found that N2 but not NH3 dominated fertilizer-derived gaseous N losses, accounting for 78 to 85 % of total gaseous N losses. Ammonia losses amounted to only 13-18%, N2O losses to 1-3 % and NO losses to 1% of applied manure-N. In the context of the ecosystem total N budget, our results show that N2 losses are a so far overlooked key component of the N balance in montane grasslands. Understanding controls of N2 loss is therefore an indispensable prerequisite for the development of grassland management strategies targeted to improve N use efficiency.