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Monitoring soil greenhouse gas emissions from managed grasslands

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Grasslands in Central Europe are of enormous social, ecological and economical importance. They are intensively managed, but the influence of different common practices (i.e. fertilization, harvesting) on the total greenhouse gas budget of grasslands is not fully understood, yet. In addition, it is unknown how these ecosystems will react due to climate change. Increasing temperatures and changing precipitation will likely have an effect on productivity of grasslands and on bio-geo-chemical processes responsible for emissions of carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O).

In the frame of the TERENO Project (www.tereno.net), a long-term observatory has been implemented in the Ammer catchment, southern Germany. Acting as an in situ global change experiment, 36 big lysimeters (1 m2 section, 150 cm height) have been translocated along an altitudinal gradient, including three sites ranging from 600 to 860 meters above sea level. In addition, two treatments have been considered, corresponding to different management intensities. The overall aim of the pre-alpine TERENO observatory is improving our understanding of the consequences of climate change and management on productivity, greenhouse gas balance, soil nutritional status, nutrient leaching and hydrology of grasslands.

Two of the sites are equipped with a fully automated measurement system in order to continuously and accurately monitor the soil-atmosphere greenhouse gas exchange. Thus, a stainless steel chamber (1 m2 section, 80 cm height) is controlled by a robotized system. The chamber is hanging on a metal structure which can move both vertically and horizontally, so that the chamber is able to be set onto each of the lysimeters placed on the field. Furthermore, the headspace of the chamber is connected with a gas tube to a Quantum Cascade Laser, which continuously measures CO_2, CH4, N2O and H_2O mixing ratios. The chamber acts as a static chamber and sets for 15 minutes onto each lysimeter; changes with time in the mixing ratios of the targeted gases are used to calculate exchange rates of the different molecules. The system allows for precise calculation of soil greenhouse gas fluxes at sub-daily resolution.

Here, we will show the importance of high temporal frequency measurements for unbiased estimations of annual greenhouse gas emission budgets. Extremely high pulses of CH4 and N2O emissions after fertilizer application were observed, but in some occasions lasted for a couple of hours, only, before returning to baseline levels. Pulse response after fertilization was not always immediate. Especially for CO_2, a clear diel pattern was observed, with emission rates varying by more than 100 % between early morning and midday. In summary, implications of the spatial and temporal dynamics of soil N2O, CH4 and CO_2 emissions will be discussed and recommendations for avoiding under- and/or overestimation of exchange rates will be given.