3 years of N_2O and CH_4 exchange of intensive and extensive managed pre-alpine grassland ecosystems: current vs. climate change conditions

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Embedded into the TERENO project, IMK-IFU has installed 3 lysimeter networks with a total of 36 undisturbed intact grassland soil cores (diameter 1m, depth 1.4m) at three grassland sites differing in altitude (850m, 750m, 600m), in South-Bavaria, Germany. Lysimeters were partly translocated from higher elevation to lower elevation and other soil cores stay at original sites as controls. With decreasing altitude, mean annual temperature increases (up to 2.5°C) and mean annual precipitation slightly decreases. In addition to the space for time in-situ climate change approach the total of 36 lysimeters are split into treatments of intensive and extensive grassland management. Soil N_2O and CH_4 exchange were measured mainly by a new developed automatic chamber robot system in high temporal resolution.

Across the three sites N_2O emissions under current climatic conditions varied between 0.13 and 3.0 kg N_2O-N ha^{-1} yr^{-1}. Overall N_2O emissions were rather small and differences between intensive (app. 250 kg N addition by manure) and extensive (120 kg N addition by manure) management of 0.95 and 0.73 kg N_2O-N ha^{-1} yr^{-1} (average of three sites and three years) were surprisingly low. Main reason for the low N_2O emissions of the sites investigated, is caused by the dominance of N_2 emissions (> 30 kg N ha-1 yr-1; measured with intact soil cores and the N_2/ He substitution method). Beside fertilization events N_2O emissions during frost-thaw events were a second hot moment highly contributing to annual N_2O emissions. Climate change slightly increased N_2O emissions after fertilization events but since the frequency and intensity of frost-thaw events increase under climate change conditions due to less snow coverage, differences of N_2O emissions between current and climate change conditions were small. Nevertheless, N mineralization rates increase with climate change but surplus N is either taken up by plants and/ or lost by again by a much higher stimulation of N_2 emissions.

CH_4 exchange of the three grassland ecosystems investigated was dominated by methane uptake except sporadic emissions under wet/ anaerobic conditions after snowmelt and high pulse emissions at times of manure application. Uptake rates varied between -1.40 and – 0.47 kg C ha^{-1} yr^{-1} and were generally higher under extensive management (average of three sites and three years 0.88 vs. 0.78 kg C ha^{-1} yr^{-1}). Since CH_4 emissions at times of manure application significantly reduced the grassland CH4 sink strength, this differences was mainly caused by the lower number of manuring events (2 vs. 5) in the extensive treatment. In contrast to N_2O emissions, warmer and better aerated soil conditions significantly increased the sink strength of atmospheric CH_4 of the pre-alpine grassland ecosystems under climate change conditions.

So far our study reveals that impacts of climate change on N_2O emissions of pre-alpine grassland soils are rather small since N trace gas emissions in our systems are dominated rather by N_2 than by N_2O and elevated emissions after fertilization events are often compensated by increased N_2O emissions during frost-thaw events. Even though climate change increases the CH_4 sink strength, due to the comparable low GWP the overall impact on the total GHG balance of pre-alpine grassland systems is low and mainly driven by changes in the soil-plant carbon cycling.