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Greenhouse gas fluxes over managed grasslands in Central Europe

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The biosphere-atmosphere exchange of the three greenhouse gases (GHG) carbon dioxide (CO_2), nitrous oxide (N2O) and methane (CH4) over managed grasslands in Central Europe is strongly affected by site-specific management strategies. While most in-situ GHG measurements focus on the quantification of CO_2 exchange, long-term N2O and CH4 flux measurements at ecosystem scale remain scarce, which in turn makes the profound evaluation of environmental impacts at site level challenging.

In this synthesis we collected ecosystem CO_2, N2O and CH4 fluxes from 14 managed grassland sites, quantified by eddy covariance or chamber techniques. On average, the investigated grasslands were a CO_2 sink (-1783 to -91 g CO_2 m-2 yr-1), but a N2O source (18 to 638 g CO_2-eq. m-2 yr-1), and either a CH4 sink or source (-9 to 488 g CO_2-eq. m-2 yr-1). The net GHG balance (NGB) was calculated for nine sites where measurements of all three GHGs were available and were found between -2761 and -58 g CO_2-eq. m-2 yr-1, whereby emissions of N2O and CH4 offset concurrent CO_2 uptake by on average 21 $\pm$ 6% across sites. NGB was positive for one site during a restoration year with ploughing. Soil variables were generally poor predictors for observed N2O and CH4 fluxes, but their predictive power varied considerably within years. However, after site-specific data normalization it was possible to identify environmental conditions that indicated enhanced GHG source and/or sink activity ('sweet spots'), with high explanatory values for normalized overall fluxes across sites. The application of animal slurry to grasslands resulted in elevated N2O and CH4 emissions. Overall, the N2O-N emission factor across sites was found at 1.8 $\pm$ 0.5%, but it varied considerably at site level among the years (between 0.1 and 8.6%). Generally, grassland management led to increased N2O and CH4 emissions, but the CO_2 sink strength was the most dominant component of the annual GHG budget.