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Seasonal variability of CH4 and N2O fluxes over a managed temperate mountain grassland

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The quantification of greenhouse gas (GHG) budgets on a global scale is an important step in assessing the effect of anthropogenic and biogenic controls on a future climate. In the past, measurements of CO_2 fluxes were conducted over a wide array of ecosystems, leading to a better understanding of its exchange patterns on different time scales and more sophisticated models. However, only few studies quantified the fluxes of the other two major GHG, methane (CH4) and nitrous oxide (N2O), mainly due to expensive sensors and their time-consuming maintenance. In addition, early CH4 and N2O measurements mainly focused on ecosystems with presumably high emissions of CH4 (e.g. wetlands) or N2O (e.g. heavily fertilized crops). In recent years, devices for CH4 and N2O measurements became widely available and more studies are conducted over sites that exert small and often close-to-zero fluxes. Despite recent advances in sensor sensitivity and stability, the quantification of CH4 and N2O exchange rates remains challenging.
Here we present measurements of CH4 and N2O exchange rates of a temperate mountain grassland managed as a hay meadow near the village Neustift in the Stubai Valley, Austria, that started in April 2010 by means of the eddy covariance method. The three wind components and the speed of sound were acquired at a time resolution of 20 Hz, while CH4 and N2O mixing ratios were recorded at 2 Hz by a quantum cascade laser absorption spectrometer (QCL-AS). Fluxes of both compounds were calculated using the virtual disjunct eddy covariance method (vDEC). For better comparability fluxes of N2O and CH4 were also converted to g CO_2-equivalents and compared to the CO_2 exchange at the same site. In addition to exchange rates, challenges regarding the calculation of GHG fluxes at the investigated grassland site will also be discussed.

In 2011, deposition of CH4 was recorded on 9 days with average uptake rates of -0.6 nmol m-2 s-1. Peak emissions of up to 12.9 nmol m-2 s-1 were found in October, about 10 days after the 3rd cutting of the meadow. First results showed cumulative fluxes amounting to a net emission of CH4, corresponding to 58.6 g CO_2-equivalents m-2 in 2011. N2O showed net deposition fluxes on 38 days and maximum uptake rates of -0.3 nmol m-2 s-1 during 7 consecutive days with nitrogen uptake in April 2011. Peak emissions of more than 1.2 nmol m-2 s-1 were observed at the end of November, about one month after fertilization. In total, the meadow was a source of N2O (118.9 g CO_2-equivalents m-2). In comparison, cumulative fluxes of CO_2 in 2011 resulted in a net uptake of -70.4 g CO_2 m-2.

Distinct diurnal cycles could be observed for N2O, e.g. in April with peak uptake rates of more than -0.7 nmol m-2 s-1 around noon, or in August with peak midday emissions of around 0.8 nmol m-2 s-1. Diurnal cycles of CH4 were less pronounced and more error-prone due to spikes in methane mixing ratios and fluxes, but nevertheless showed a tendency of methane release during the day, around noon up to 10.1 nmol m-2 s-1 in September.