Seasonal variability of CH_4 and N_2O fluxes over a managed temperate mountain grassland

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ABOUT

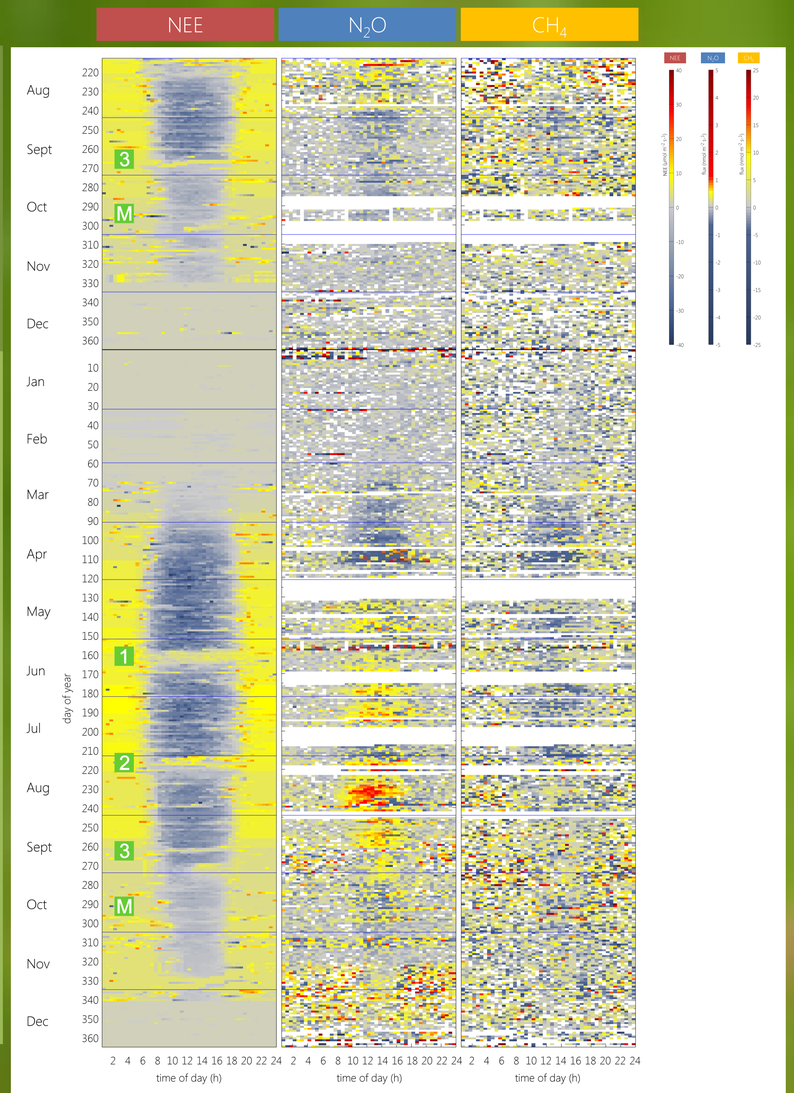
The quantification and understanding of the greenhouse gas (GHG) exchange between terrestrial ecosystems and the atmosphere is crucial when trying to assess the effect of anthropogenic and biogenic controls on a future climate. Using the eddy covariance method, fluxes of CO_2 have been measured over a wide array of ecosystems, while measurements of the other two major GHG, methane (CH_4) and nitrous oxide (N_2O), were only conducted by few groups due to expensive scalar sensors and their time-consuming maintenance. These first measurements mainly focused on ecosystems that were believed to represent significant sources for CH_4 (e.g. wetlands) or N_2O (e.g. heavily fertilized crops).

With CH_4 and N_2O measurement devices now being widely available, more measurements are made over sites that are characterized by relatively small and often close-to-zero fluxes, and despite recent advances in sensor sensitivity and stability, the quantification of these two GHG remains challenging.

METHODS

Here we report on the CO_2, CH_4 and N_2O exchange measured in 2011 at a temperate mountain grassland managed as a hay meadow near the village Neustift in the Stubai Valley, Austria, by means of the eddy covariance method. The three wind components, the speed of sound and the CO_2 mole densities were acquired at a time resolution of 20 Hz and used to calculate true eddy covariance CO_2 fluxes.

CH_4 and N_2O mixing ratios were recorded at 2 Hz by a quantum cascade laser absorption spectrometer (QCL-AS), resulting in a disjunct time series when compared to the 20 Hz wind data. Fluxes of both compounds were then calculated using the virtual disjunct eddy covariance method (vDEC). Mixing ratios of CH_4 and N_2O were corrected for the cross-talk effect of water as described in earlier studies.



HALF-HOURLY FLUXES
Figure 1

Diurnal cycles and half-hourly fluxes of methane and nitrous oxide during the measurement campaign in 2010 and 2011.
White numbers on green background show management events: 1st cut → June | 2nd cut → August | 3rd cut → September | manure spreading → October. Snow cover: 26 November 2010 – 10 March 2011 | 7 December – 31 December 2011.

Calculation of N_2O and CH_4 fluxes proved to be difficult due to often erratic nighttime fluxes, mainly because of calm and stable nighttime conditions resulting in unsteady mixing ratios and a general overestimation of fluxes. To correct for this effect, a FIR-filter using Hamming-windowing was used in the flux calculation of both compounds.

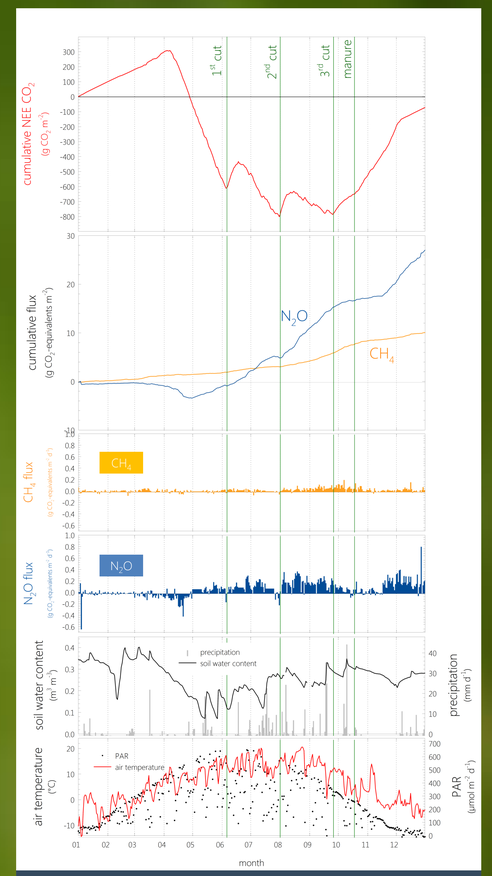
98 % of all half-hourly N_2O fluxes were found between -1 and +1 nmol m^{-2} s^{-1}, and 93 % of all CH_4 fluxes were between -10 and +10 nmol m^{-2} s^{-1}.

Diurnal cycles indicated an uptake of N_2O starting after snowmelt in March and continuing throughout April 2011, with peak rates of -0.5 nmol m^{-2} s^{-1} early afternoon. Strongest emissions were observed in August 2011, up to 0.7 nmol m^{-2} s^{-1}.

Especially during nighttime CH_4 fluxes were often erratic. However, during daytime in certain months methane showed clear deposition fluxes, the strongest were observed in July 2011, up to -2.2 nmol m^{-2} s^{-1} around noon.

DIURNAL CYCLES 2011
Figure 2

Study site near Neustift, Austria



CUMULATIVE FLUXES
Figure 3

Cumulative fluxes of CO_2 resulted in a net uptake of -70.4 g CO_2 m^{-2}. In 2011, the meadow acted as a source for both methane and nitrous oxide (10 and 27 g CO_2-equivalents m^{-2}, respectively).

Uptake and emission of N_2O / CH_4 were found on 88 / 54 (up to -0.6 / -0.1 g CO_2-equivalents m^{-2} d^{-1}) and 277 / 311 days (up to 0.8 / 0.2 g CO_2-equivalents m^{-2} d^{-1}), respectively.

CO_2	↓ -70	GHG-Total - 33
CH_4	↑ +10	
N_2O	↑ +27	

numbers are given in g CO_2-equivalent m^{-2} yr^{-1}

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