

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

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about

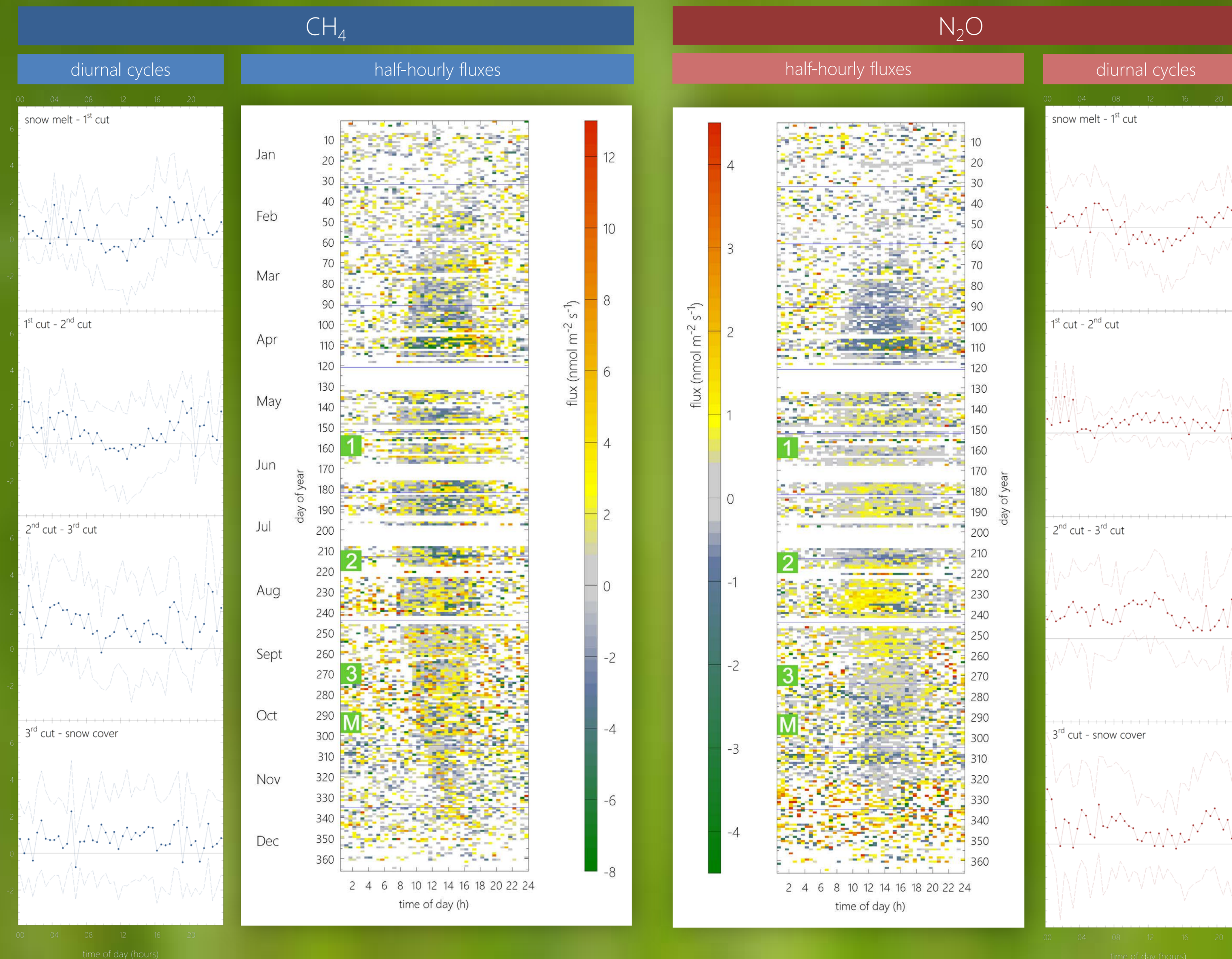
The quantification and understanding of the greenhouse gas (GHG) exchange between terrestrial ecosystems and the atmosphere is crucial when trying to assess the effect of anthropogenic and biogenic controls on a future climate. Using the eddy covariance method, fluxes of CO₂ have been measured over a wide array of ecosystems, while measurements of the other two major GHG, methane (CH₄) and nitrous oxide (N₂O), 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 CH₄ (e.g. wetlands) or N₂O (e.g. heavily fertilized crops).

With CH₄ and N₂O 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 CO₂, CH₄ and N₂O 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 CO₂ mole densities were acquired at a time resolution of 20 Hz and used to calculate true eddy covariance CO₂ fluxes.

CH₄ and N₂O 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 CH₄ and N₂O were then corrected for the cross-talk effect of water as described in earlier studies.



methane fluxes 2011

Figure 1

Calculation of methane 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 methane fluxes. To correct for this effect, a FIR-filter using Hamming-windowing in combination with subsequent outlier removal was applied to the half-hourly CH₄ flux data.

Highest average uptake rates of -1.2 nmol m⁻² s⁻¹ were observed around noon in the time period between snow melt and the 1st cut, while nighttime fluxes showed emissions of up to 2.3 nmol m⁻² s⁻¹ during the same period. This pattern was very similar between the 1st and 2nd cut, but with generally lower uptake rates of -0.8 nmol m⁻² s⁻¹.

After the 2nd cut diurnal cycles indicated general emission of methane from the meadow to the atmosphere, on average 0.9 and 0.5 nmol m⁻² s⁻¹ after the 2nd and 3rd cut, respectively.

nitrous oxide fluxes 2011

Figure 1

Diurnal cycles indicated an uptake of N₂O before the 1st cut, with peak rates of -0.4 nmol m⁻² s⁻¹ early afternoon. During this period, uptake started after 9 a.m. and continued until after 5 p.m., before it switched back to emission. Uptake was especially strong after snowmelt towards the end of March and then throughout April.

Before the 2nd cut, the meadow acted as a source of N₂O with average peak emission rates of 0.4 nmol m⁻² s⁻¹ during the day. Emissions further increased to 0.8 nmol m⁻² s⁻¹ after the 2nd cut. Between the 3rd cut and snow cover, emission patterns exhibited close-to-zero fluxes around noon and emissions of generally below 1 nmol m⁻² s⁻¹ during nighttime.

Especially during snow cover fluxes of nitrous oxide showed a somewhat erratic behavior. In contrast to CH₄ fluxes, no FIR-filter was applied. Therefore, the flux contribution of low frequency eddies, especially towards the end of the year, may be overestimated.

Figure 1

Diurnal cycles and half-hourly fluxes of methane and nitrous oxide during the measurement campaign in 2011. White letters on green background show management dates: 1st cut → 6 June | 2nd cut → 1 August | 3rd cut → 26 September | manure spreading → 18 October. Snow cover: 1 January – 10 March | 7 December – 31 December



Study site near Neustift, Austria

Figure 2

cumulative fluxes

Figure 2

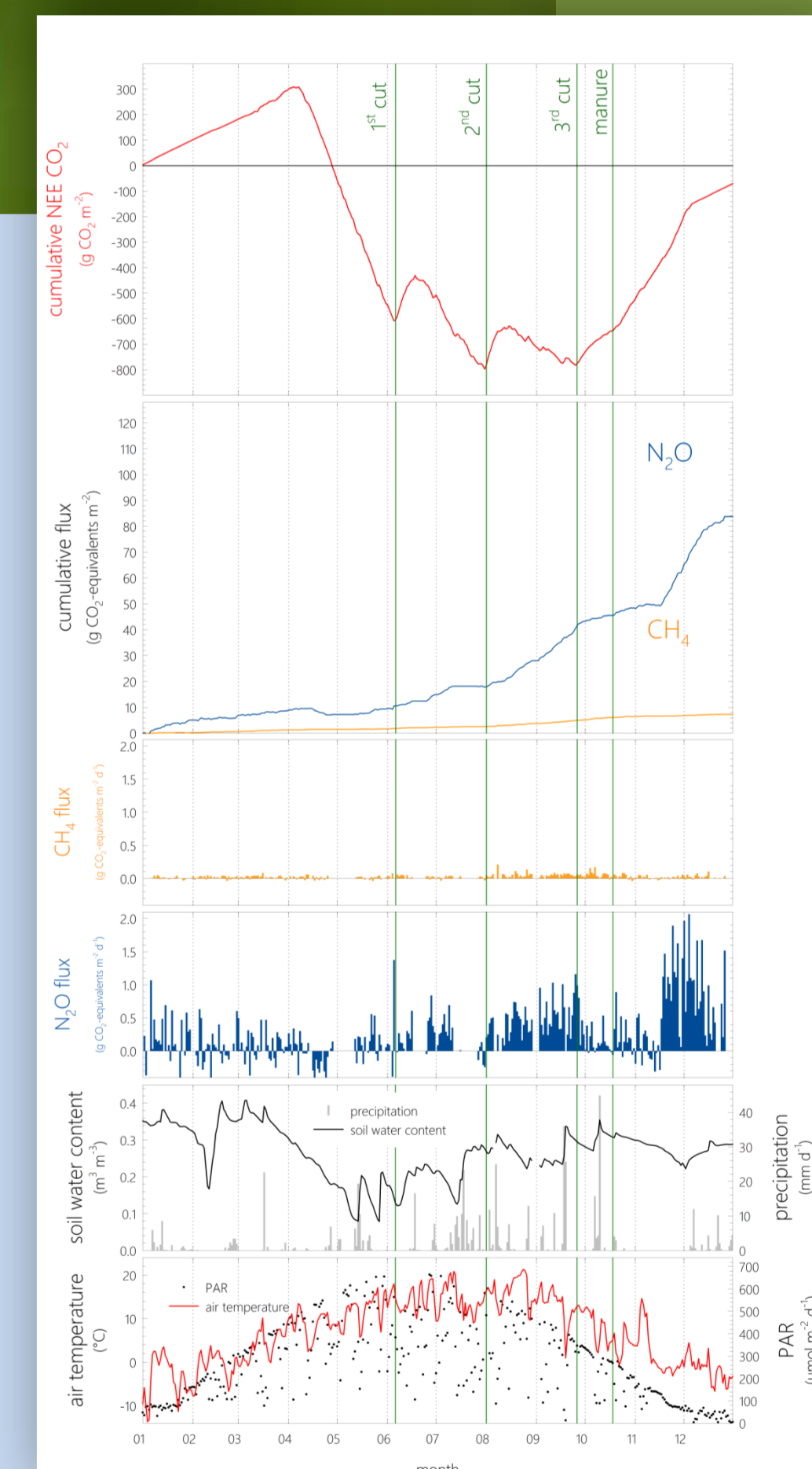
Cumulative fluxes of CO₂ resulted in a net uptake of -70.4 g CO₂ m⁻².

In 2011, the meadow acted as a source for both methane and nitrous oxide (7 and 84 g CO₂-equivalents m⁻² yr⁻¹, respectively).

Uptake of methane was recorded on 56 days, highest deposition fluxes were observed at the end of October and towards the end of May (-0.04 g CO₂-equivalents m⁻² d⁻¹). The meadow emitted methane on 233 days, the highest uptake rate of 0.2 g CO₂-equivalents m⁻² d⁻¹ was found one week after the 2nd cut.

Similarly, uptake and emission of nitrous oxide were found on 63 (up to -0.5 g CO₂-equivalents m⁻² d⁻¹) and 226 days (up to 2.1 g CO₂-equivalents m⁻² d⁻¹), respectively. Fluxes for N₂O may still be overestimated due to erratic emission fluxes towards the end of the year, especially after snow cover and during the night.

Methane fluxes were objected to rigorous filtering to correct for erratic nighttime volume-mixing-ratios and a general overestimation of nighttime fluxes, resulting in considerably lower flux numbers than previous estimates. This data treatment may also be necessary for nitrous oxide.



CO ₂	↓ -70	GHG-Total +21
CH ₄	↑ +7	
N ₂ O	↑ +84	
numbers are given in g CO ₂ -equivalent m ⁻² yr ⁻¹		