CARBON MONOXIDE EXCHANGE ABOVE A TEMPERATE MOUNTAIN GRASSLAND

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BACKGROUND

Carbon monoxide (CO) is a toxic trace gas with an atmospheric lifetime of 1-3 months and an average atmospheric concentration of 100 ppb. CO mole fractions exhibit a pronounced seasonal cycle with lows in summer and highs in winter. Carbon monoxide has an **indirect global warming potential** by increasing the lifetime of methane (CH_4), as the main sink of CO is the reaction with the hydroxyl (OH) radical, which in turn is also the main sink for CH_4. Regarding the warming potential, it is estimated that 100 kg CO are equivalent to an emission of 5 kg CH_4 (Wild and Prather, 2000). In addition, carbon monoxide interferes with the building and destruction of **ozone**. Emission into and uptake from the atmosphere of CO are thus relevant for global climate and regional air quality. Sources and sinks of CO on a global scale are still highly uncertain, mainly due to general scarcity of empirical data and the lack of ecosystem-scale CO exchange measurements, i.e. CO flux data that encompass all sources and sinks within an ecosystem.

METHODS

Here we report on the CH_4, N_2O and CO exchange measured between March and October 2013 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, N_2O and CO mixing ratios were recorded at 1-5 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 then corrected for the cross-talk effect of water as described in earlier studies.

FLUXES

Figure 1

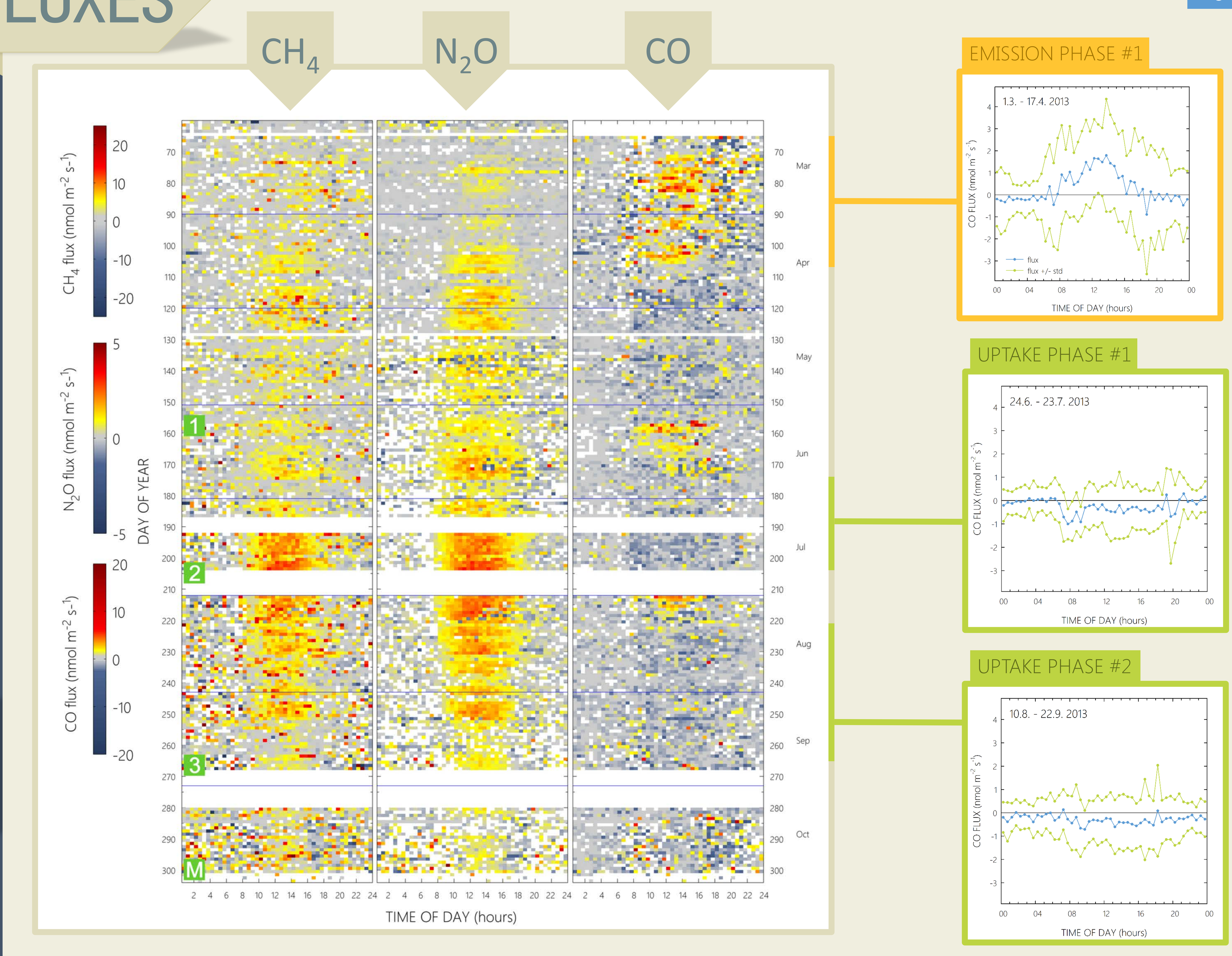

FIGURE 1. LEFT: Half-hourly fluxes of CH_4, N_2O and CO between 1 March and 31 October 2013. Numbers 1,2,3 denote dates where the meadow was cut, M shows the date of manure spreading. RIGHT: Average diurnal cycles of CO exchange during selected time periods. The meadow was permanently snow-covered until approx. 19 March.

The study site near Neustift, Austria.

REGRESSION ANALYSIS

Table 1

	multiple r^2	important regressors	partial correlation	p
EMISSION PHASE #1, n = 43 days	0.40 *	T_{air}	-0.42	*
		NEE	0.27	n.s.
		SHF	0.31	n.s.
UPTAKE PHASE #1, n = 22 days	0.77 *	PAR	-0.62	*
		H	0.63	*
		LE	0.51	n.s.
		NEE	-0.56	*
UPTAKE PHASE #2, n = 43 days	0.55 *	RHA	0.55	***
		SHF	0.42	*
		T_{air}	-0.39	*
ALL DATA, n = 206 days	0.43 ***	NEE	0.44	***
		SHF	0.25	***
		T_{air}	-0.26	***

TABLE 1. Results of a **multiple linear regression** analysis using daily average values, with linearized[1] CO flux as the dependent variable and CO volume mixing ratio, relative air humidity (RHA), air (T_{air}) and soil temperature, photosynthetically active radiation (PAR), soil water content, soil heat flux (SHF), net ecocsystem exchange (NEE), and fluxes of latent (LE) and sensible (H) heat as independent parameters.

[1]Box-Cox transformation

DRIVERS?

Figure 3

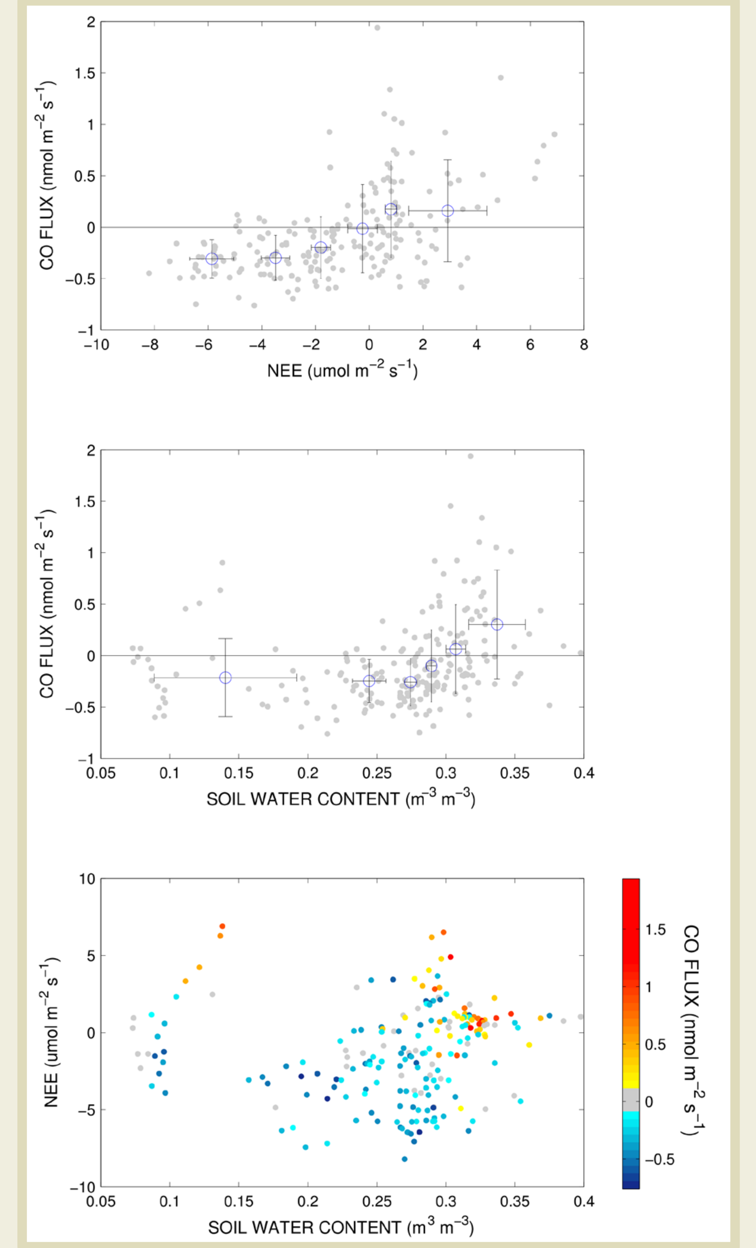

FIGURE 3. CO daily average exchange (grey dots) versus NEE (upper panel) and soil water content (middle panel). Blue circles are bin averages (35 days per bin), error bars represent the standard deviation within each bin. In the lower panel, cooler colors indicate uptake of CO by the meadow, warmer colors emission. Manage-ment events were excluded from the analysis.

RESULTS

FLUX DYNAMICS

Between March and October 2013, the meadow was a **weak sink for CO** and a source of CH_4 and N_2O (Fig.1 and 2). We observed clear CO emissions in March when the meadow alternated between being snow-free and snow-covered.

Similar to cumulative NEE exchange at the site, the meadow became a net sink for CO some weeks after snowmelt and until the 1st cut. The cutting event turned the meadow into a CO source for about one week before it again became a net sink. This behavior recurred after the 2nd cut (Fig. 2).

DRIVERS?

Our chosen set of ancillary data explained 43 % of observed CO fluxes when all data were pooled, and up to 77 % on shorter time scales (Table 1). Generally, CO was transported to the meadow when CO2 deposition occurred at low or intermediate soil water content (Fig. 3).

GLOBAL WARMING POTENTIAL

Due to the low fluxes associated with CO exchange at the study site, it is unlikely that it is a significant factor regarding the GWP of the meadow.

First analyses showed that the meadow was a strong sink for CO_2 in 2013, with a cumulative uptake of -400 g CO_2 m^{-2} (corresponds to 109 g CO_2-C m^{-2}) between January and December.

Between March and October 2013, this uptake was offset by 26 % due to CH_4 and N_2O emissions, resulting in a preliminary GHG-total of -294 g CO_2 m^{-2}. However, CH_4 and N_2O are also emitted during the cold winter months, data of which were not available for this analysis. Assuming a similar GHG flux behavior during the winter months like in 2011 at the same site, we would expect CH_4 and N_2O to offset NEE by 40 % over the whole year.

Cumulative carbon exchange associated with CH_4 and CO fluxes between March and October were only 0.39 and -0.02 g C m^{-2}, i.e. not significant for the carbon balance of the meadow.

CUMULATIVE

Figure 2

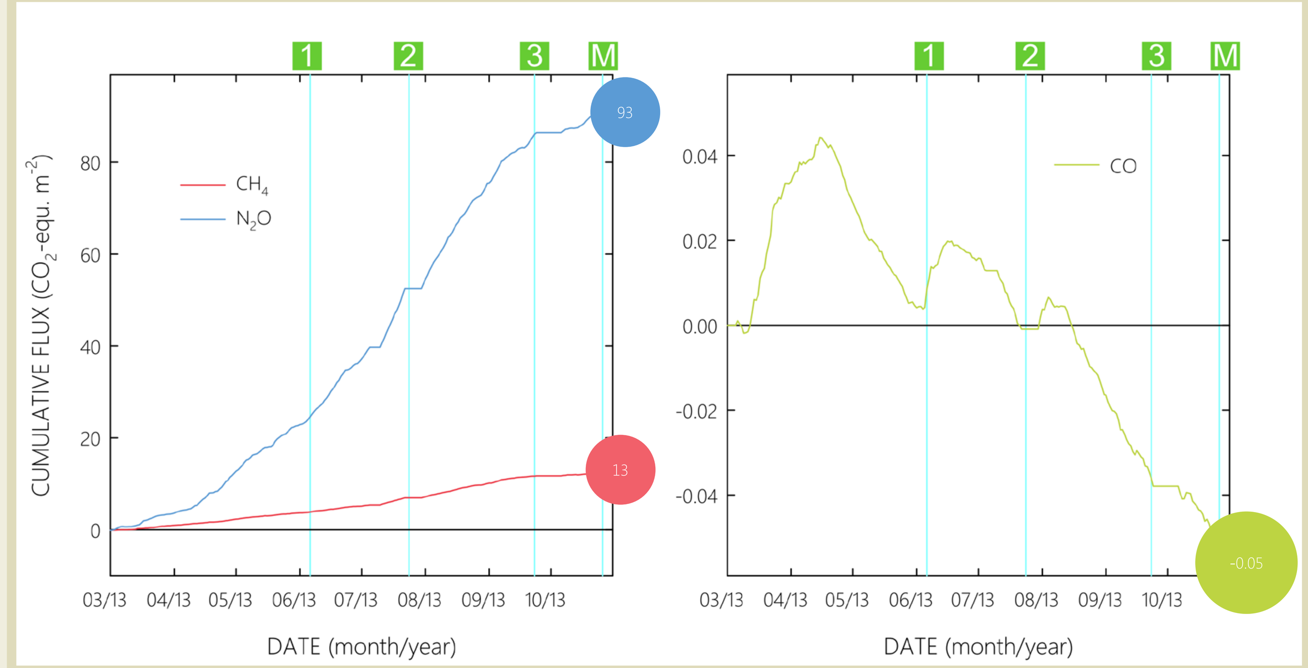

FIGURE 2. Cumulative GHG fluxes in 2013 expressed as CO_2-equivalents. Vertical lines show management dates, numbers 1, 2 and 3 in green squares indicate the 1st, 2nd and 3rd cutting of the meadow, respectively, while M denotes manure spreading.

Reference: Wild O., Prather M.J. (2000) Excitation of the primary tropospheric chemical mode in a global three-dimensional model. *Journal of Geophysical Research* **105**, 24647-24647.

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