Comm. Appl. Biol. Sci, 79/1, 2014

YEARLY FOLLOW-UP OF METHANE TURBULENT EXCHANGE OVER AN INTENSIVELY GRAZED PASTURE IN BELGIUM

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INTRODUCTION

Methane emissions account for 8 % of the EU-15 GHG emissions and livestock generates 40 % of these emissions (European Commission, 2009). These fluxes are mainly measured in metabolic chambers with the drawback of bringing the cattle in an unfamiliar environment. Recent technological advances in spectroscopy now permit methane flux measurement using eddy covariance. This micrometeorological method has numerous strengths. It can measure fluxes in situ, continuously and across broad areas. This provides information about grassland and cattle emission behaviour throughout the year and across a broad range of climatic conditions. We present here a one year monitoring of methane exchange between an intensively grazed grassland and the atmosphere obtained using the eddy-covariance method.

MATERIAL AND METHODS

Methane fluxes exchanged by a grazed grassland were measured continuously since June 2012 at the Dorinne Terrestrial Observatory (50° 18' 44" N; 4° 58' 07" E; 248 m asl.) in Belgium. The site is an intensively pastured grassland of 4.2 ha managed according to the regional common practices where up to 30 Belgian Blue cows are grazing simultaneously.

Flux measurements were made with the eddy covariance technique, using a fast CH_4 analyzer (Picarro G2311-f) and a sonic anemometer (Campbell Csat3) placed in the centre of the grassland, 2.6 m above ground. Air sampled near the anemometer is pulled through a 6.85 m warmed hosepipe and a 1 µm filter (ACRO50 PTFE 1 µm) before getting to the analyzer. Wind velocity and gas concentrations (CO_2, CH_4 and H_2O) were synchronized by the analyzer and stored at 10 Hz. Turbulent fluxes were calculated per half hour using EddyFlux (EDDY Software). All calculations were based on standard eddy covariance computation schemes (Aubinet *et al.*, 2012; Aubinet *et al.*, 2000). Data were corrected for wind direction (Rebmann *et al.*, 2012), high frequency losses (Foken *et al.*, 2012) and were filtered for non-stationarity (Foken *et al.*, 2012; Foken & Wichura, 1996) and for low friction velocity (u*) events (Aubinet *et al.*, 2012; Goulden *et al.*, 1996). For now, no gap-filling method has been applied.

Various micro-meteorological and soil variables including global and net radiation (CNR4), air temperature and moisture (RHT2), soil temperature at 2, 5, 10, 25 and 50 cm (Pt 1000), soil moisture at 5, 25 and 50 cm (ThetaProbe), atmospheric pressure (barometer) and precipitation (52203 Tipping Bucket Rain Gauge) were continuously measured. Biomass growth was measured by periodically collecting biomass in exclusion zones. Stocking rate evolution was also recorded.

Instantaneous position of the cows in the pasture is an important aspect. Indeed, movements of the moving sources (cows) in and out of the area from which the measured flux is originating (often called the footprint zone) will make the effective stocking rate a varying quantity while the stocking rate of the whole pasture is fixed. This effect will only add a random error on the deduced flux per livestock unit (LSU) if we can assume a mean random distribution of cattle in the pasture. If cattle distribution is not random (cows being systematically more present in specific zones), a systematic error will also appear. In this paper, in the absence of geo-localization tools, we will rely on the hypothesis of mean random distribution.

However, three one-day confinement events were organized. During these events, cattle were confined in approximately a third of the grassland upwind from the mast, covering roughly the footprint zone. During these events, effective stocking rate is therefore better constrained. Further work will tackle the geo-localisation aspects to improve our flux per livestock unit estimations.

RESULTS

Methane fluxes are measured on site since June 2012 with a data coverage above 95 %. During this period, stocking rates (SR) ranged from 0 to 30 livestock Unit (LSU) per ha.

Fluxes monitoring

Flux measurements collected each half are represented in Figure 1.

When no cattle are present on the grassland, fluxes are generally ranging from 0 to 0.05 µmol m^{-2} s^{-1} with very few negative fluxes. The grassland is thus acting as a methane source the whole year round, even when no cows are present.

When cattle are present on the grassland, emissions were much higher, generally ranging from 0 to 1 µmol m^{-2} s^{-1}.

During confinement periods, fluxes were high, generally ranging from 0.05 to 0.8 µmol m^{-2} s^{-1}. During these periods, fluxes did not go down too low because some cattle were always present in the footprint.

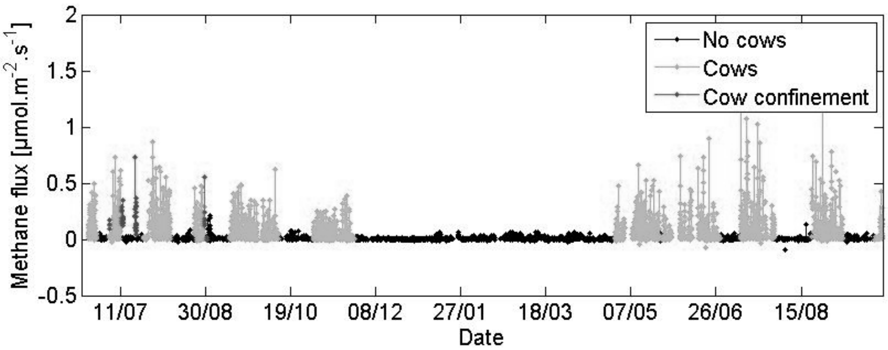

Figure 1 Methane flux against time on our site for 3 different cattle configurations

Enteric emissions

Fluxes were strongly linked to stocking rate with a regression curve corresponding to the equation: F_{CH4}=[10.6 (±0.5) x SR + 14.4 (±3.0)] x 10^{-3} (Figure 2). This line is fitted assuming a random distribution of cows on the pasture.

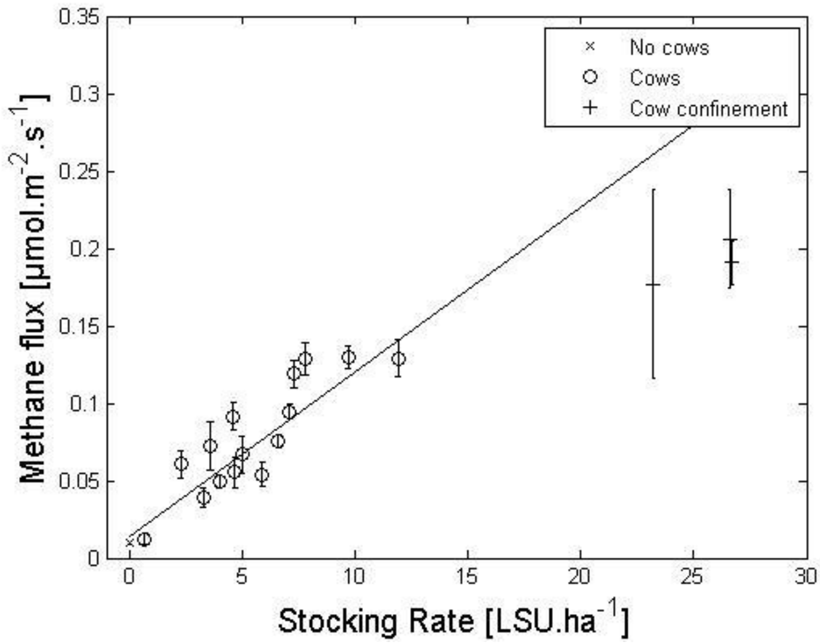

Figure 2 Impact of stocking rate on methane fluxes, assuming a random cattle distribution. Error bars are standard errors of the mean.

When cows are present, emissions reach a peak in the afternoon (Figure 3).

Without cows, a daily cycle was also observed; emissions are higher during the day than during the night. Averaged half-hour fluxes were always found below 0.016 µmol m^{-2} s^{-1} (data not shown).

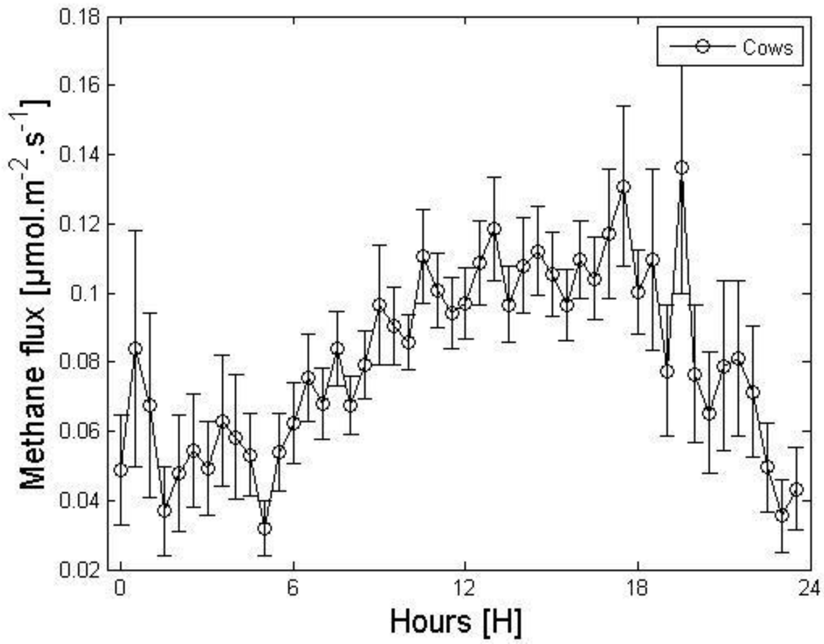

Figure 3 Daily evolution of methane fluxes during cattle presence. Error bars are standard errors of the mean.

Environmental drivers

When no cattle were present on the grassland, environmental drivers of CH_4 fluxes were investigated. Soil moisture and soil temperature at 5 cm depth could affect methanotroph and methanogen bacteria activity. As both drivers are correlated, we divided each dataset in 3 categories according to the value of the other driver. However no significant impact on CH_4 fluxes was found. (Figure 4 for moisture, data not shown for temperature).

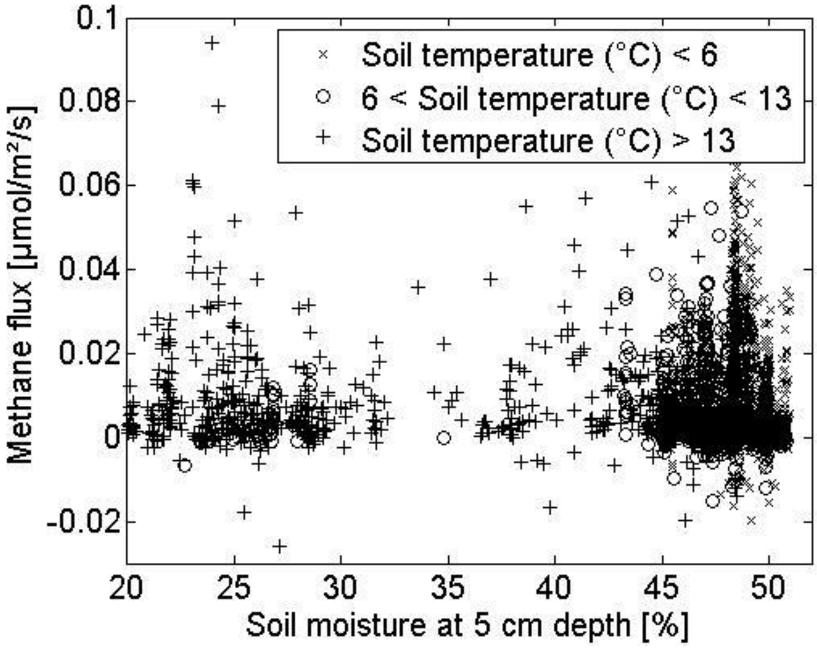

Figure 4 Impact of volumetric soil moisture on methane fluxes during cow-free periods for 3 categories of soil temperature

DISCUSSION

Fluxes monitoring

European soils are generally considered as methane sinks due to methane oxidation (Smith, 2000). However, our site was a net methane emitter, even during cattle absence. Although uncommon, this behaviour is in agreement with some other sites and could be linked to the soil high water content (Smith, 2000).

During grazing periods fluxes were highly variable. This phenomenon could be due to cow digestion rhythm and cow movements in and out the measurement footprint zone. Cattle geo-localization is needed to disentangle these two potential causes.

Enteric emissions

Methane emissions were correlated with cattle stocking rate with a slope of 50.8 ± 2.5 kg CH_4 LSU^{-1} $year^{-1}$ (against 57 kg CH_4 LSU^{-1} $year^{-1}$ for IPCC 2006 tier 1 emission factor).

Daily fluxes evolution was characterized by a peak of emissions in the afternoon which is partly consistent with other studies performed on sheep (Dengel *et al.*, 2011; Judd, 1999).

Environmental drivers

Environmental drivers were searched for periods without cattle. Considered drivers (soil temperature and soil moisture) were not affecting methane fluxes in a significant way. A study from Smith *et al.* (2000) identified water table height, bulk density, water-filled pore space, gas diffusivity, soil water content and temperature as the more common drivers. Additional attention will be given to these factors.

Soil volumetric moisture was generally found between 43 and 52 % which correspond to high water content. This could explain the absence of methane oxidation on the grassland.

CONCLUSION

In the absence of cattle, no net methane sink has been observed. This observation is in disagreement with most of the European sites (Smith *et al.*, 2000). No obvious relation can be established between methane emissions and soil temperature or moisture at present, drivers are therefore still to be identified.

Methane emissions were correlated with stocking rate with a slope of 53.5 ± 2.5 kg CH_4 LSU^{-1} $year^{-1}$) (against 57 kg CH_4 LSU^{-1} $year^{-1}$ for IPCC, 2006 tier 1 emission factor). As eddy covariance is rarely used for the measurement of fluxes from moving sources, this result is comforting us in the belief that our measurement method is appropriate. Ongoing activities include developments on cattle geo-localisation and activity devices in order to improve and validate our measurement method.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge funding from the Walloon region (Direction Générale Opérationnelle de l'Agriculture, des Ressources naturelles et de l'Environnement, Département du Développement, Direction de la Recherche, Belgium. Project no. D31-1235, January 2010 to December 2011. Project no. D31-1278, January 2012 to December 2013) and from the French Community of Belgium (ARC grant for Concerted Research Actions).

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