Chamber-based Soil Methane Flux Measurement

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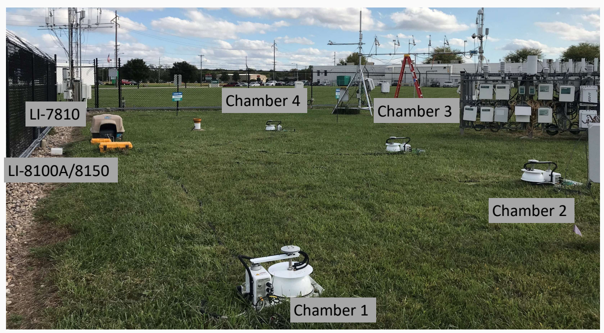
Introduction

In the literature, datasets for methane oxidation rate in soil are limited due to the lack of high accuracy and precision methane analyzers and automated measurement systems. Recently, LI-COR developed a methane analyzer (LI-7810, LI-COR Biosciences) which can be used for chamber-based soil CH_4 flux measurements. We integrated this methane analyzer into an automated soil CO_2 flux system (LI-8100A/8150). Field soil CO_2 and CH_4 flux measurements were conducted at LI-COR's field station from early September, 2018 to the end of November, 2018. In this report, we first describe some key specifications of the analyzer, then preliminary field soil CH_4 flux data will be reported.

LI-7810 Key Specs

Range	Precision @ 5s	Accuracy
CH_4: 0.1-50 ppm	≈0.25 ppb	2 ppb @ 2000 ppb, 25 °C
CO_2: 1-10000 ppm	≈1.5 ppm	1.5 % @ 300-700 ppm, 25 °C
H_2O: 0.100-60 ppt	≈20 ppm	1.5 % @ 0.5-60 ppt, 25 °C

Field setup: A CH_4 analyzer (LI-7810) was integrated into 4 chamber multiplexed system (LI-8100A/8150 system, outlet of LI-8100 AIU). Soil temperature and moisture at each chamber at the depth of 5 cm were also measured. The clocks of the LI-8100A and the LI-7810 were synchronized by a computer at the field station.



CH_4 flux calculation:

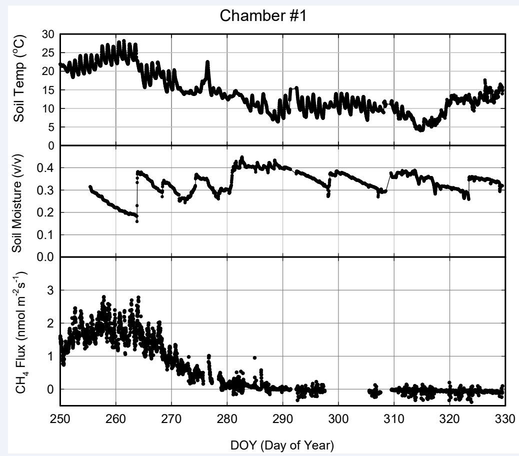
$$F_{CH4} = \frac{VP(1-W_o)}{RST}\frac{dCH_4}{dt}$$

Where:

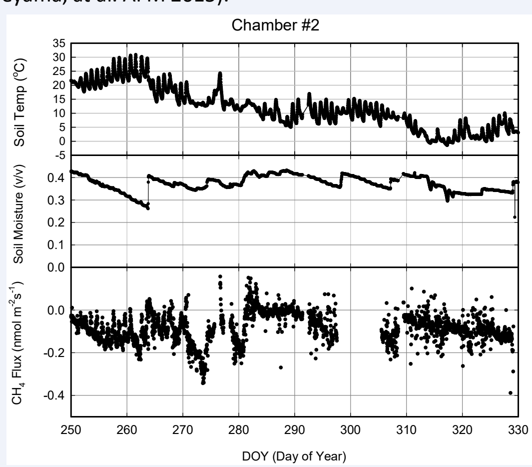
F_{CH4}:	soil CH_4 flux (mol $m^{-2}s^{-1}$)
V:	chamber volume (m^3)
P:	atmospheric pressure (Pa)
W_o:	initial water vapor mole fraction (mol mol^{-1})
R:	gas constant
S:	soil area (m^2)
T:	chamber temperature (K)
$\frac{dCH4}{dt}$:	rate of CH_4 change (mol $mol^{-1}s^{-1}$)

Results: The soil at our field site is a Sharpsburg silty clay loam (Typic Argiudall) and the ground cover is primarily fescues (*Festuca* spp.) with a mean vegetation height of approximately 5 cm. From the 4-chamber CH_4 flux data, two patterns in seasonal variation of CH_4 flux were observed, which are illustrated below using the datasets from Chamber #1 and #2 as examples.

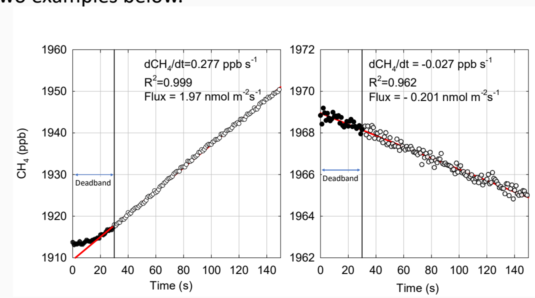
Pattern 1. From Chamber #1 and #3, the soil was a CH_4 source in the summer with a rate of up to 2.8 nmol $m^{-2}s^{-1}$ even when the soil moisture was dropped to 0.2 (v/v). The high emission rate at our field site was unexpected. Additional work is needed to determine why the high rate of emission occurred over this grassland. After DOY 300, the soil became a CH_4 sink with a typical rate of -0.2 nmol $m^{-2}s^{-1}$.



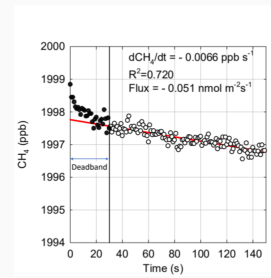
Pattern 2: From Chamber #2 and #4, except for a brief duration (DOY 281-283), the soil was a CH_4 sink with a typical rate of -0.2 nmol $m^{-2}s^{-1}$. The maximum rate was around -0.35 nmol $m^{-2}s^{-1}$. This rate was expected and consistent with published rates (e.g. Ueyama, at al. AFM 2015).



Example of time serial CH_4 concentration: With a LI-8100-104 chamber (chamber volume of 4013 cm^3 and soil area of 318 cm^2), linear regression coefficients were normally higher than 0.9 when the CH_4 flux was higher than 0.1 nmol $m^{-2}s^{-1}$. see the two examples below.



Based on our seasonal long-term methane flux data, we feel confident that this configuration of a closed chamber system can resolve a minimum flux as low as 0.05 nmol $m^{-2}s^{-1}$. See an example to the right. Over the two minutes observation, chamber CH_4 concentration decreased by approximately 0.79 ppb (0.0066X120=0.792 ppb).



This is about 3 times the precision of this CH_4 analyzer (~0.25 ppb). This should give us enough confidence in the slope estimation using linear or exponential regression.

Conclusions

1. Depending on the location, the silty clay loam soil with fescues vegetation at the Lincoln Nebraska can be a CH_4 source or sink in the summertime. The emission rate can be as high as 2.8 nmol $m^{-2}s^{-1}$.
2. After DOY 300, the soil is a CH_4 sink with a typical rate of – 0.2 nmol $m^{-2}s^{-1}$.
3. With our current instrument setup (LI-8100A/8150+LI-7810), the minimum detect methane flux is approximately 0.05 nmol $m^{-2}s^{-1}$.

References

Ueyama M., et al., 2015. Methane uptake in a temperate forest soil using continuous closed-chamber measurement. *Agricultural and Forest Meteorology*. 213:1-9

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