Carbon dioxide and methane fluxes from the transitional zone of a Virginia ephemeral wetland

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INTRODUCTION

The spatial and temporal controls mediating the switch between anaerobic and aerobic respiration within soils located in transitional zones adjacent to ephemeral wetlands remains unclear. As ephemeral wetlands dry down, a soil moisture gradient develops in adjacent transitional zones resulting in changes to the soil environment—moving from anoxic to oxic conditions. Under oxic conditions, aerobic decomposition and CO_2 fluxes should dominate, while under anoxic conditions, anaerobic decomposition and CH_4 emissions should be more prominent.

RESEARCH QUESTIONS

1) What are the spatial controls on anaerobic and aerobic respiration in transitional zones along Lake Arnold, an ephemeral wetland in north-central Virginia
2) What are the temporal dynamics of anaerobic and aerobic respiration in transitional zones along Lake Arnold as measured by CO_2/CH_4 fluxes?

METHODS

Three 20 m transects were established in June 2014 (figure 1) along Lake Arnold—an ephemeral wetland located at the Blandy Experimental Farm in north-central Virginia (39.397639, -77.888579).

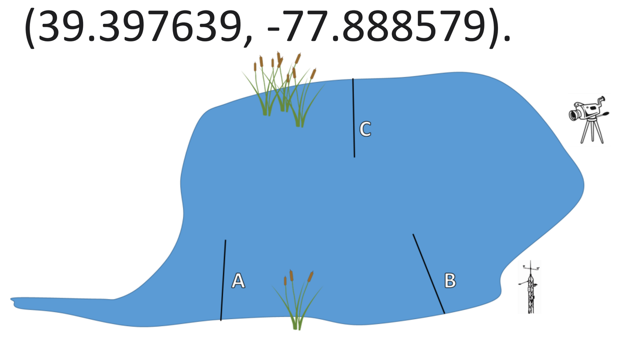

Figure 1. Transect layout and lake schematic

Transects started at the initial lake edge established by max. lake extent (figure 3). Measurements were taken weekly when possible.

Measurements at 0, 10, 20 m distance along transect
- CH_4 gas samples taken at even time intervals using a non-steady state chamber). Samples run on Varian 3400 VX GC with 60/80 Carboxen-1000 column (figure 2).
- VWC every 15 minutes at 5, 20, 50 cm soil depth

Measurements at 0, 5, 10, 15, 20 m distance along transect:
- CO_2 soil efflux (EGM-4, SRC-1; PP Systems)
- VWC 0 – 20 cm soil depth (Campbell HydroSense TDR)
- Soil temperature at 5, 12, and 20 cm
- Soil redox potential at 5 and 20 cm (custom platinum electrode and Ag/AgCl reference electrode; Fisher Scientific).

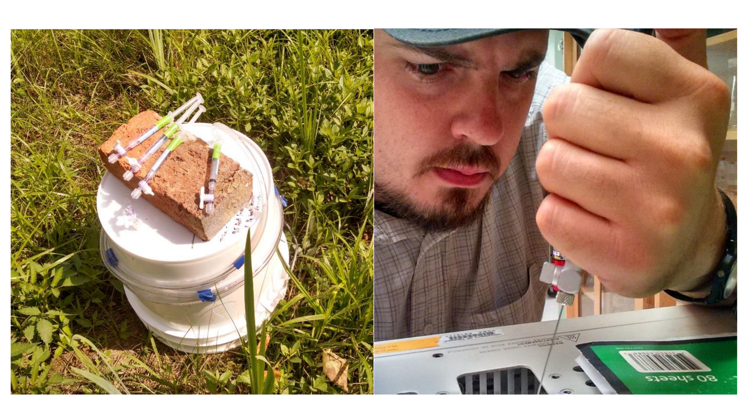

Figure 2. Non-steady state, custom chamber (left); Injecting samples into the GC (right).

Rainfall, air temperature, and relative humidity were also measured with a 1.5 m met tower (figure 5, middle).

*More about Redox potential measurements in soil and methods on probe construction can be found at: http://goo.gl/RlRqL2

RESULTS

Lake Arnold began to dry out steadily starting in early June through September. Max lake depth was ~ 1.75 m and dropped to 0.4 m by September 7, 2014. The lake was at reported record levels on June 1, 2014.

Figure 3. Areal extent of Lake Arnold on indicated dates. Areas approximated from GPS data. Background image Google Earth December 2013.

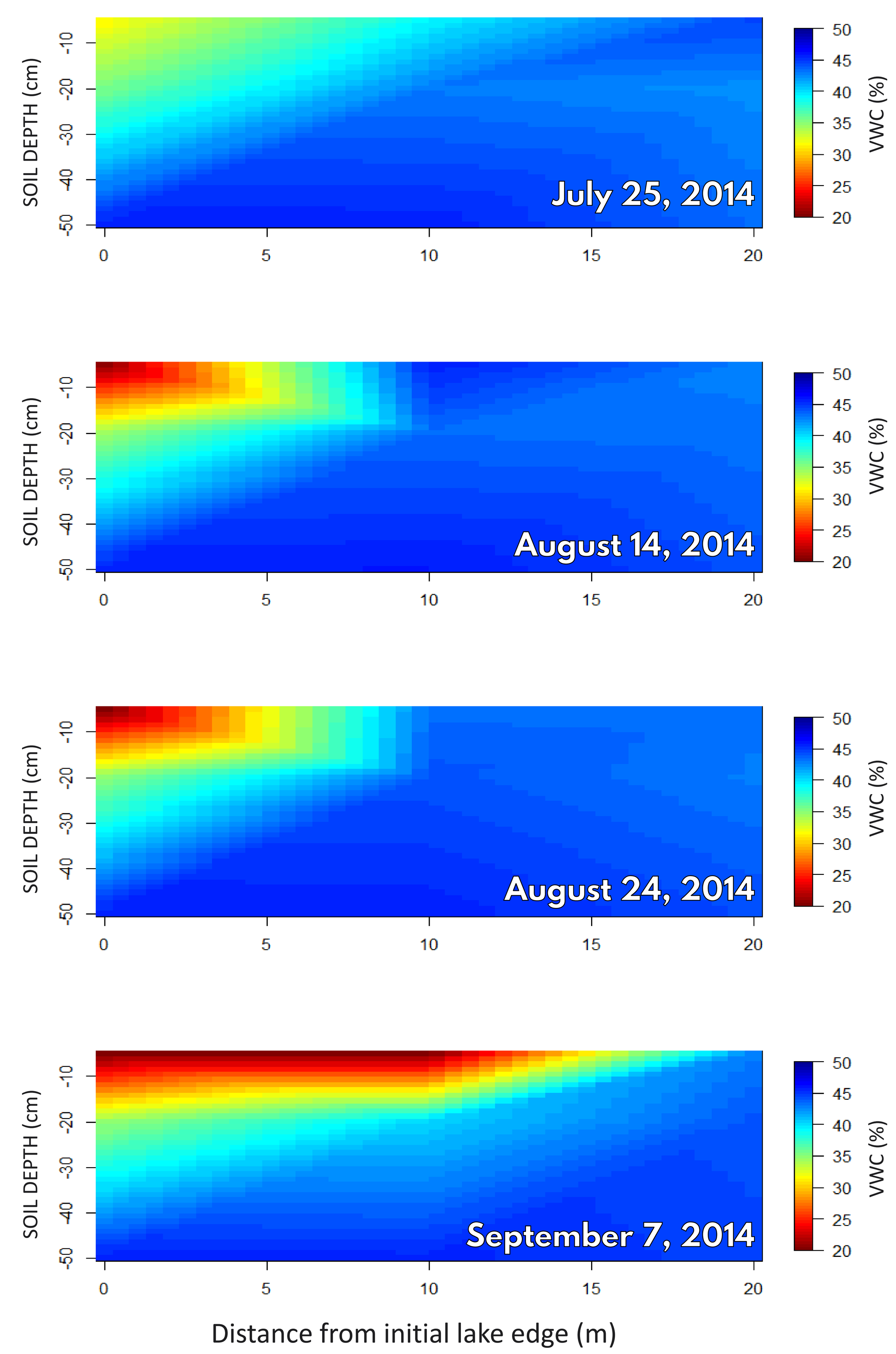

Figure 4. Soil moisture from 5 – 50 cm depth along transect A from July 25 – September 7, 2014. Note the slow dry down at depth and at points farther from the initial lake edge as soils remain wet long after surface water is gone. Graphs created using the akima and fields packages in R.

Figure 5. Field site pictures. At top, transect B during mid-July—water has receded to the 10 m distance. In the middle, our met station. At bottom, side view of transect A in early July as the water has receded past the 20 m distance. Vegetation quickly covered exposed soil as water receded.

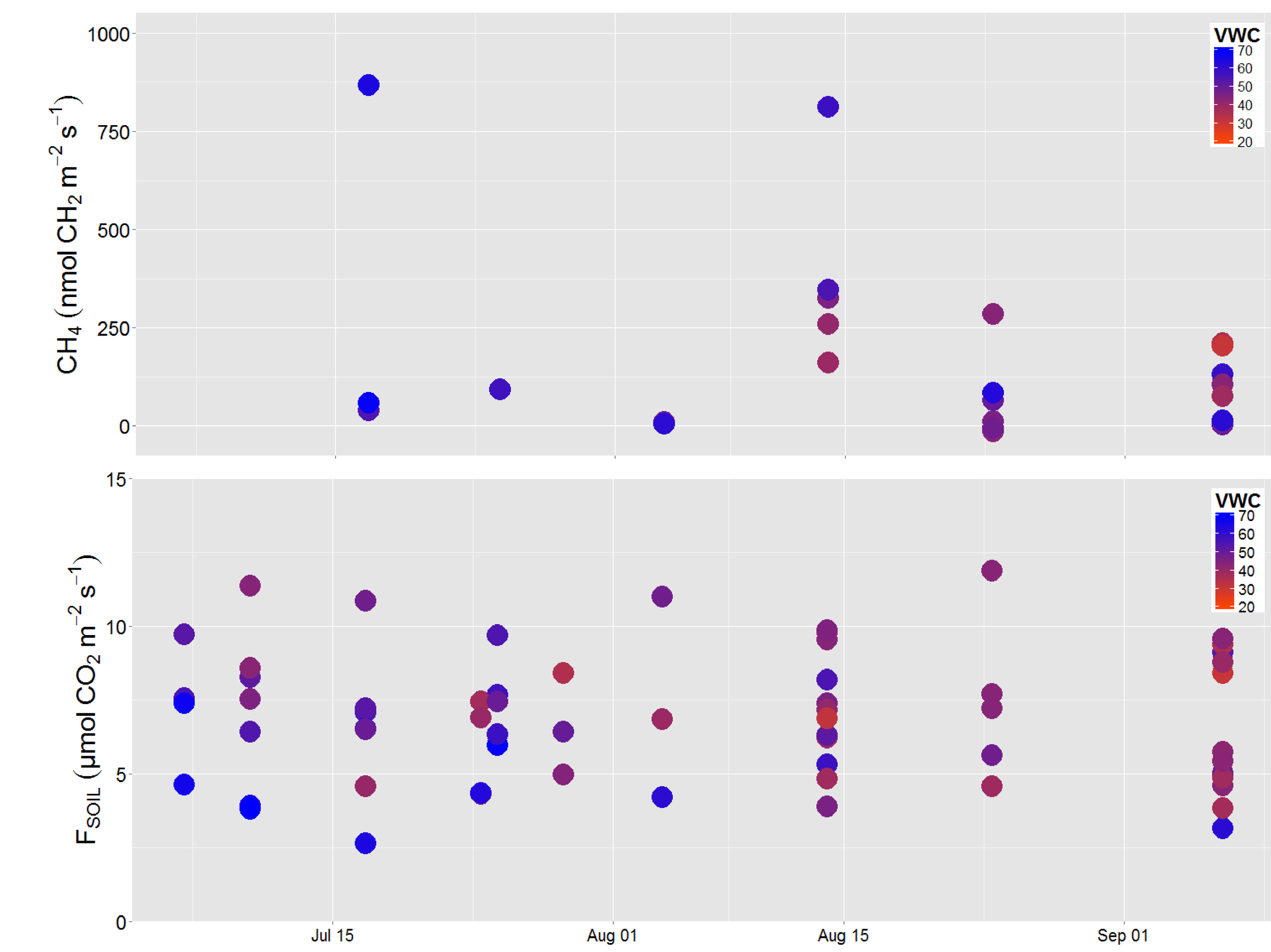

Figure 6. At top, CH_4 fluxes by date. At bottom, CO_2 fluxes by date. The intensity of color indicates volumetric water content (VWC) as indicated in legend (from HydroSense msmts).

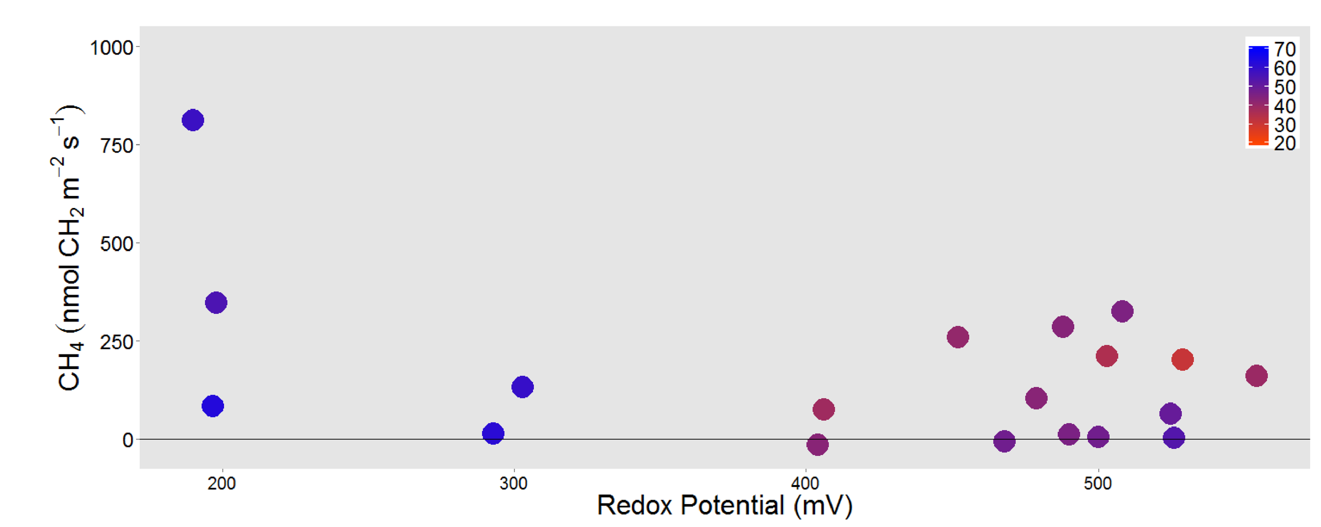

Figure 7. CH_4 fluxes against redox potential (mV). The intensity of color indicates volumetric water content (VWC) as indicated in legend (from HydroSense msmts). Lower redox potential indicates a reduced soil environment, while a higher redox potential indicates a more oxidized soil environment.

CONCLUSIONS

- CH_4 fluxes are strongly correlated with soil moisture, with larger fluxes occurring during periods of increased soil moisture
- CH_4 fluxes decreased during the growing season as soils dried
- CO_2 fluxes peaked later than CH_4 fluxes during the growing season at each point along the transect
- Redox potential appears to be tightly coupled with CH_4 fluxes as expected, though more data would better quantify this relationship
- Lake Arnold was at record depth this year and soils dried more slowly than expected, discommoding the study

FUTURE DIRECTIONS

During the spring 2015 semester, as part of a planned undergraduate research project at the University of Virginia in cooperation with researchers at Virginia Commonwealth University, we are going to perform a controlled incubation experiment to calculate CH_4 production rates of soils from our transects in a manner similar to that of Kannenberg et al (2015)* and quantify methanotrophic communities using qPCR.

*Kannenberg et al. (2015) Patterns of potential methanogenesis along soil moisture gradients following drying and rewetting in Midwestern prairie pothole wetlands. Wetlands. (Pub. date and volume no. TBA)

LEARN MORE!

A full break-down of our experiment, with more detailed methods, background and information about the Blandy Experimental Farm, and most importantly a pretty terrific time-lapse video of Lake Arnold taken during the summer are all online. Scan the QR code or visit:

http://goo.gl/bQwvS8