An Analysis of Soil CO_2 Emissions in a Temperate Deciduous Forest Ecosystem

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INTRODUCTION

- The production and emission of carbon dioxide (CO_2) from soils, referred to as soil respiration (Rs), has a significant influence on the global carbon balance.
- This stored organic matter is returned to the atmosphere as CO_2 through belowground decomposition of organic matter by microbial communities (heterotrophic respiration) and metabolic activity of roots and mycorrhizae (autotrophic respiration).
- In this study, we explore temporal and spatial dynamics of Rs in a temperate deciduous forest and how it is influenced by climatic controls.

METHODS

- Research for this project is conducted at a 90-year-old deciduous hardwood forest, part of the Turkey Point Research Station located north of Lake Erie in southern Ontario.
- A combination of two research methods are used:

1. Chamber-based measurement

- Measures gas exchange across a soil surface.
- Chambers seal a known volume of air and the flux is calculated from the rate of increase of CO_2 over time (measured as the slope).

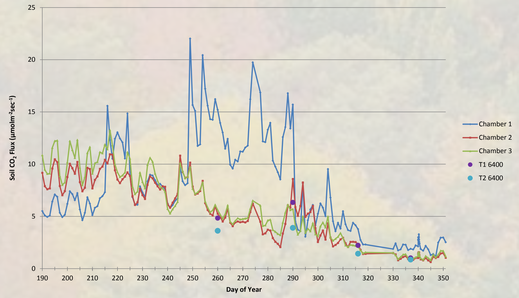
2. Eddy covariance

- Based on the turbulent transport theory.
- used to estimate fluxes from the covariance between the vertical wind speed and the gas concentration at a measured height above the surface.

- To better capture the spatial variability of Rs, a portable soil CO_2 flux system (LI-6400) was also used along two 50-m transects.

RESULTS AND DISCUSSION

- Figure 1 shows the Rs values collected from both the LI-8100A and the two transects measured with the LI-6400, T1 and T2:



Chamber 1 is displaying incredibly high flux values in the summer months, most likely due to its location on a litter pile causing high decomposition rates.

Figure 1. Daily soil CO_2 flux averages (July 9th-December 17th, 2014).

- The seasonality of Rs coincided with the seasonal climate patterns.
- Figure 2 shows the positively correlated relationship between Rs and soil temperature.

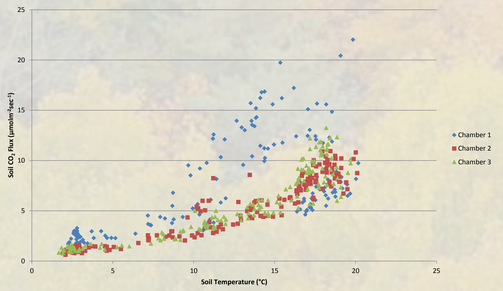


Figure 2.Daily Soil CO_2 flux averages vs. soil temperature.

- Taking into account a coupled climate-carbon cycle model, the mean surface temperature is predicted to rise by 8°C by the year 2100[1], significantly higher than the current IPCC estimate (3.5°-2.4°C)[2], illustrating the vast potential soils have to impact our climate.
- Temperature sensitivity of soil is typically expressed as the temperature coefficient (Q_{10})[3], which is the factor by which the respiration rate will change after a temperature rise of 10°. The Q_{10} of our study site was found to be 2.38.
- Comparing the two chamber systems, they both measured within one standard deviation of each other indicating that the long-term automatic chamber site is representative of the surrounding area.

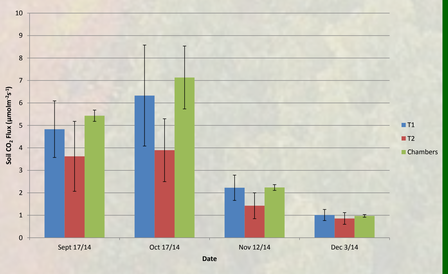


Figure 3. LI-8100A chamber soil CO_2 flux vs. LI-6400 (September-December 2014).

CONCLUSIONS

- We found that the seasonal trends of Rs follows closely that of soil temperature.
- Though spatial variability is problematic when studying Rs, our combination of chamber-based methods have enabled us to determine that our long-term monitoring site is representative of the surrounding forest.
- One of the main factors that make Rs a high interest topic is its sensitive relationship with future climate change. Because Rs is positively correlated with temperature, as Earth's temperatures rise carbon flux rates will inevitably increase as well.

FUTURE WORK

- Additional chambers will be added to the LI-8100A system to allow for a larger data set.
- Rs data from an additional research site planted in 1939 will be included in the 2015 analysis to compare natural vs. planted site characteristics.
- Various models will be explored to further investigate the impact of changes in soil moisture and temperature. By looking at previous responses of the forest to climate change and extreme weather events, predictions for the future can be determined.

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REFERENCES

1. Luo, Y., Wan, S., Hui, D., Wallace, L. Acclimatization of soil respiration to warming in a tall grass prairie. *Nature* **(413)**, 622-625 (2001).
2. Edenhofer, O., et al. IPCC, 2014. Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change. *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014)
3. Graf, A., Weihermuller, L., Huisman, J., Herbst, M., Bauer, J., Vereecken, J. Measurement depth effects on the apparent temperature sensitivity of soil respiration in field studies. *Biogeosciences* **(5)**, 1175-1188 (2008).