Measuring ecosystem CO_2 emission sources in a northern hardwood forest

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Introduction

Forests represent an important carbon sink that partially offsets rising levels of atmospheric CO_2 (Goodale et al., 2002). However, carbon that is stored in forest trees and soil is vulnerable to loss, and could potentially return to the atmosphere through respiration. We investigated the age of respired CO_2 to determine whether forest respiration contains older carbon from soils and trees, or is composed of "young" recently-photosynthesized carbon.

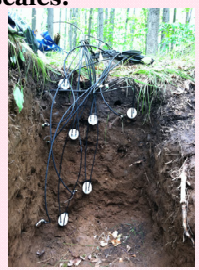
Using radiocarbon (14C) measurements we assessed the age of CO2 respired from soils, tree trunks, and the whole forest canopy, to see whether any of these sources emitted older, stored carbon.

Research Questions:

1) How old is CO_2 respired from soil??
2) Do tree trunks respire recently-fixed carbon, or older "bomb" carbon from reserves?
3) Can "bomb" carbon from soils or tree trunks be detected in canopy CO_2?

Methodology

Monitor respired CO_2 and $^{14}CO_2$ at nested spatial scales.



Subsurface sampling (4 pits, including a trenched pit, x 7 levels) allow us to partition soil CO_2 production by depth.

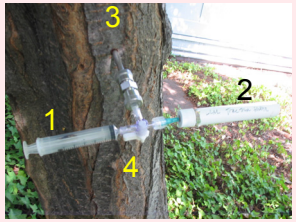
Flask air samples of $^{14}CO_2$ collected at 45feet in the air at Willow Creek AmeriFlux site in Wisconsin

Tree trunk samples of $^{14}CO_2$ collected using respiration chamber attached to trees.

Tree Trunk Chamber Design

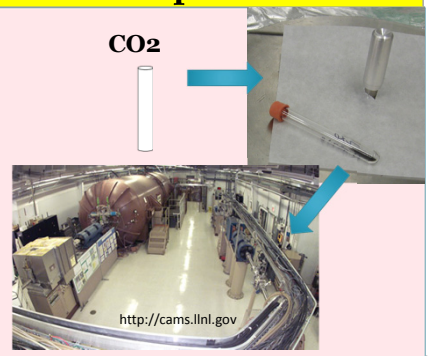
We sampled tree trunk CO_2 based on methods by Muhr et al (2011)and Ubierna et al (2009).

1. Syringe was used to create a vacuum
2. A pre-evacuated collection tube was used to collect CO_2
3. Stainless steel tube and fitting to connect collection tube to tree
4. Valve to allow CO_2 to enter vial



From Gas to Graphite

CO_2 was converted to solid carbon (graphite). By using extremely high temperatures in the presence of hydrogen and an iron catalyst, the CO_2 is reduced to graphite. The graphite is then sent through the Accelerator Mass Spectrometer to determine the carbon isotope ratio.



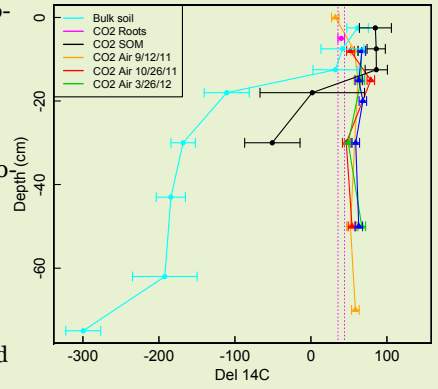
Results and Discussion

Soil Emissions

Soil CO_2 has more bomb-C than the present atmosphere suggesting the carbon is years to decades old.

Respired CO_2 is about 50-50 root respiration and organic matter decomposition.

$^{14}CO_2$ was similar throughout the profile. Deep in the soil, respired CO_2 was much younger than solid bulk soil.



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Goodale, C. et al., Forest Carbon Sinks in the Northern Hemisphere. *Ecological Applications,* 2002,12(3), 891–899 by the Ecological Society of America.

Muhr, J. et al., Radiocarbon in tree stem CO2 efflux: CO2 emitted by trees is older than expected. Poster session presented at: 44th Annual American Geological Union Fall Meeting; 2011 December 5-9; San Francisco, CA.

Ubierna, N. et al., A new method to measure carbon isotope composition of CO2 respired by trees: stem CO2 equilibration. *Functional Ecology,* 2009, 23, 1050–1058 doi: 10.1111/j.1365-2435.2009.01593.

Tree Trunk Emissions

Tree trunk emissions had amounts of 14C intermediate between soil respiration and the background atmosphere.

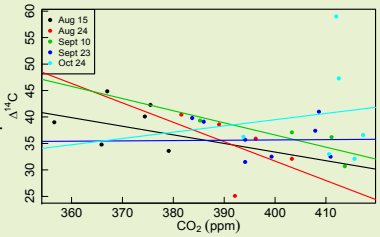
Respiration from tree stems may be a source of bomb-C to the atmosphere.

Species	Common Name	Specimen	$D^{14}C$ (‰)
Acer saccharum Marsh.	Sugar maple	1	28.0 ± 4.6
Acer saccharum Marsh.	Sugar maple	2	43.9 ± 6.7
Acer saccharum Marsh.	Sugar maple	3	36.9 ± 5.3
Tilia americana L.	Basswood	1	41.9 ± 5.5
Fraxinus americana L.	White ash	1	56.6 ± 8.2

Canopy Emissions

Impacts of soil on canopy $^{14}CO_2$ not (yet) detected.

Canopy 14C was highly variable, and there was no obvious contributions of bomb-C from soil or trees.



Currently measuring canopy $^{14}CO_2$ profiles to characterize possible soil influences.

Conclusions/ Future Research

- CO_2 produced in soils appears to be older than current photosynthesis. This CO_2 contains 30‰ more ^{14}C than the atmosphere.
- Tree trunk CO_2 were also slightly older than current photosynthesis.
- We found no clear evidence of bomb carbon from soil or tree trunk respiration in whole-ecosystem respired $14CO_2$; however, additional data and method improvements for atmospheric sampling are forthcoming.
- Future research may include more measurements of respired CO_2 from tree trunks, including a larger variety of species.

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