

Isotopic characterization of CO₂ flux and DOC along a moisture gradient at Bonanza Creek LTER, Alaska

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Introduction

The boreal forests of Alaska contain large reservoirs of carbon that have the potential to act as sources or sinks of CO₂.

Alaskan landscapes contain a wide range of vegetation and soil types. It is therefore important to consider the linkages between carbon cycling parameters, hydrologic properties and plant community attributes in order to better understand how these reservoirs of soil carbon might respond to climate change.

Four different drainage settings that contain different plant communities were analyzed in order to characterize a natural moisture gradient. In the summer of 2005, the water table of station II, containing *Drepanocladus* and *Equisitum*, was manipulated in order to assess the environmental and chemical impact associated with the landscape changes that might occur as a result of climate change. This manipulation is called the Alaska Peatland Experiment (APEX). We characterized the natural variation that occurs within different drainage settings in order to compare them to the manipulation experiment.

Carbon cycling studies utilize information such as soil carbon content and soil and CO₂ isotope composition to help characterize soils and partition the CO₂ evolved from those soils. In an effort to understand this flux partitioning along a drainage setting, we examined the isotopic characteristics of the CO₂ evolved during soil incubations as well as the dissolved organic carbon (DOC) released through leaching.

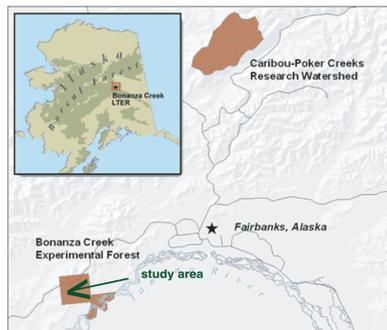
In this poster we look at the following questions:

How do environmental conditions affect CO₂ flux rates?

How does the C isotopic signature of CO₂ vary under different landscape regimes?

How does the flux partitioning (into heterotrophic, moss and roots) vary over these landscapes?

Study Area



Station I
(BZEC, 0 cm to water table, OM=82cm)



Station II (also control site for APEX)
(BZDE, water table at 20 cm, OM=9cm)



Station III
(BZG, water table at 25 cm, OM=25cm)



Station IV
(BZWB, permafrost at 64 cm, OM=25cm)



All samples and replicates were taken from the Bonanza Creek Experimental Forest outside of Fairbanks, AK. Organic matter (OM) thickness, water table depth and plant type or dominant vegetation along the drainage class gradient are given above the pictures.

Methods

Samples were collected from the top 5 cm of the moss and/or soil across the moisture gradient. These samples were removed from the site and immediately placed into glass jars with septa port lids. They were transported to Menlo Park, CA and after 48 hours the headspace gases were analyzed for CO₂ concentration. The headspace gas was analyzed for δ¹³C_{CO₂} and δ¹⁴C_{CO₂}.

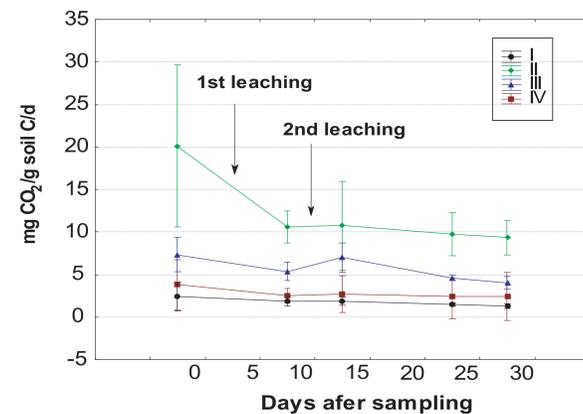
Samples were then aired out and recapped for five 48 hour periods, over the course of a month, in order to examine changes in flux rates and carbon isotope ratios over time. At days 7 and 10, the samples were leached for DOC. One month into the incubation, another 60 mL of CO₂ was removed from each sample for isotopic analysis.

The Δδ¹³C value is an index of degradation and is defined as:

$$\Delta\delta^{13}\text{C} = (\delta^{13}\text{C}_{\text{CO}_2} - \delta^{13}\text{C}_{\text{solid}})$$

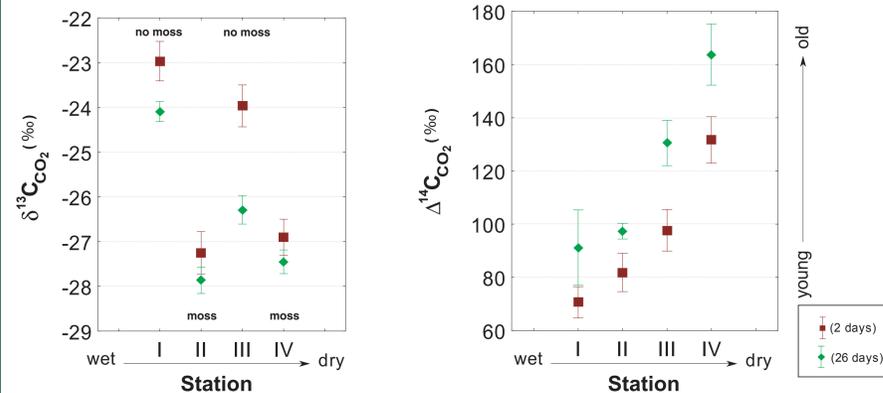
Results

Flux Rates



Flux rates for all samples decreased over the course of the one month incubation. The samples were leached with 100 mL of water twice during the incubation. The intermediate stations (II and III) had the highest flux rates.

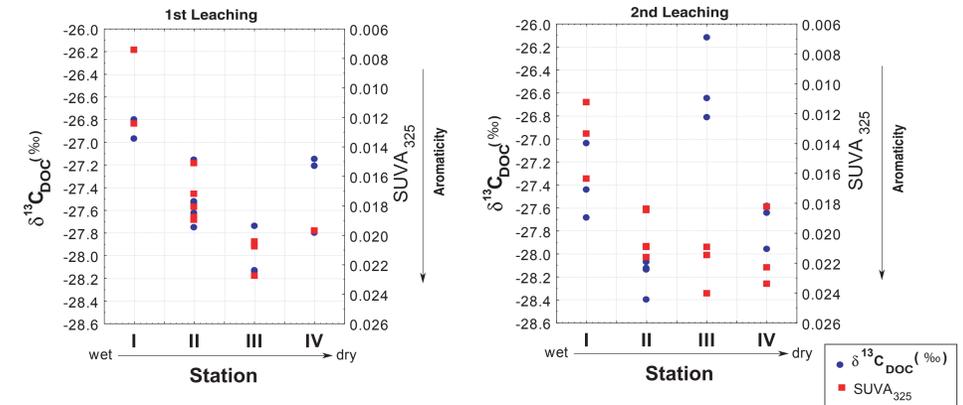
Isotope Data



Carbon isotope characteristics of gas respired during the month-long laboratory incubations. From the Δ¹⁴C data, we get an idea of the variation between ecosystems in the age of the soil carbon respired. There's a clear trend towards older carbon at the dry end of the moisture gradient.

The δ¹³C data is more elucidative of the unique mixture of flux components (roots, moss, heterotrophs) for each site. Samples taken from stations II and IV contained moss. This difference explains the heavier δ¹³C values at the sites with no moss.

DOC: isotopes and SUVA

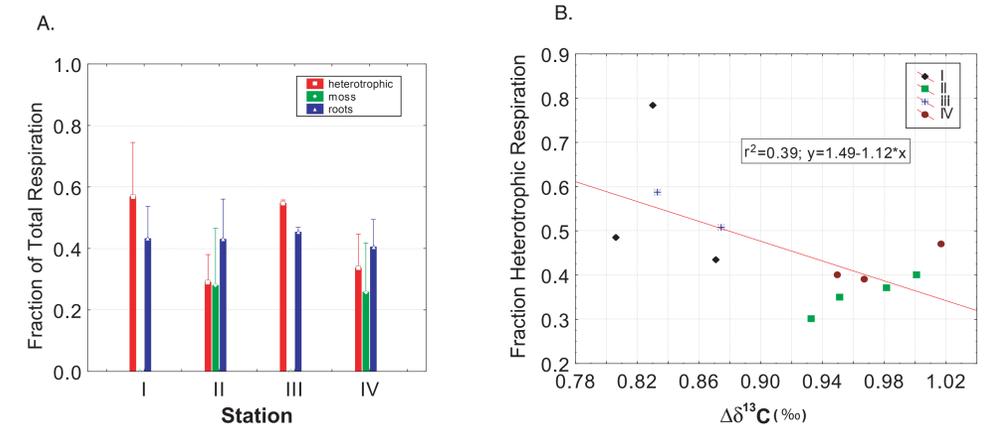


δ¹³C_{DOC} plotted with its SUVA₃₂₅. SUVA₃₂₅ is an indicator of carbon quality. The higher the SUVA₃₂₅, the more aromatic the carbon. The data from the initial leaching show good correlation between isotope and SUVA₃₂₅ trends along the gradient, indicating that the isotopes of the DOC are also an indicator of carbon quality.

The second leaching, however, shows the DOC isotope data diverging from the SUVA₃₂₅ trend at the grass site (station III). This implies that the relationship between δ¹³C and SUVA₃₂₅ is not necessarily linear and in fact, the isotope data might be illuminating changes in microbial resource availability reflected also in the CO₂ isotope data. These resource changes aren't necessarily the result of a change in carbon quality.

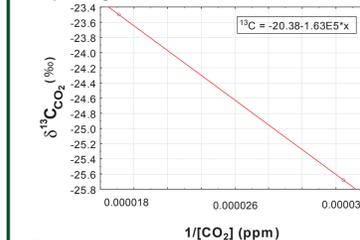
Conclusions

Flux Partitioning



A. Possible CO₂ source partitioning into heterotrophic, moss and root respiration along the gradient. For stations with no moss (I, III), the second measured isotopic signature was considered to be representative of mostly heterotrophic activity (assuming that all root related activity subsided earlier in the incubation). For the other end member (roots) keeling plots were used to determine the y intercept (or purely root signal).

Example from grass station:



Based on these assumptions, the initial isotopic signature was then partitioned for stations I and III.

At stations, II and IV, root respiration was also determined by the keeling plots. Since the second measured isotopic signature was a mixture of heterotrophic and moss respiration, we could not use it as the heterotrophic end member. Instead we used the IsoSource program developed by Phillips and Gregg (2003) to partition systems with n isotopes and > n+1 sources. We estimated the moss isotopic signature to be -30‰ (E. Kane, 2004, pers. com.). The heterotrophic signature was given a high and low estimate based on stations I and III.

B.

The fraction of heterotrophic respiration was plotted against the Δδ¹³C to gauge our model results. There is a reasonably good correlation between model results and our data. The samples and sites with the lowest fraction of heterotrophic respiration are also those with most decomposed soil.