3-2014

Forest - Atmosphere Interaction at Howland Forest

David Dail
Principal Investigator; University of Maine, Orono, david.dail@umit.maine.edu

Forest – Atmosphere Interaction at Howland Forest

Final Report

June 1, 2011 – September 30, 2013

John Lee
Environmental Physics Group
24 Greenhouse Lane
School of Forestry, UMaine
Orono, Maine 04469
(207) 581-2930

Project Goals

The overall goal of the proposed work is to understand the various (and interacting) impacts of a changing climate on carbon cycling at the Howland AmeriFlux site, representative of an important component of the North American boreal forest. Our focus is on quantitatively partitioning respiration into aboveground and belowground processes and into autotrophic and heterotrophic processes to better constrain carbon cycle models. Whole-ecosystem flux measurements generally do a poor job of separating photosynthetic uptake from respiration and cannot constrain (or assign) respiration to the different sources within an ecosystem. This partitioning is difficult, but we will take advantage of new promising technologies. Such partitioning of fluxes into individual processes can provide powerful multiple constraints to carbon cycle models because of the different pool sizes, locations, and time scales for which these processes are important. By participating in data-model comparison activities such as the North American Carbon Program (NACP) site-level syntheses, and by carrying out our own data-model fusion and uncertainty studies, we will insure that data and insights from this work directly contribute to advancing carbon cycle science. Specifically, we will

- Use eddy flux and new $\delta^{13}CO_2$ measurements to investigate partitioning of daytime fluxes into photosynthesis (GEE) and respiration.

- Test the viability of partitioning of soil and ecosystem respiration into autotrophic and heterotrophic components using experimental manipulations, model optimization, and in situ CO2 flux and $\delta^{13}CO_2$ measurements.

- Explore (using information theoretic criteria) what observational data best reduce uncertainties in simulated respiratory fluxes and below-ground processes, and how to best combine the constraining influence of different data sets.

- Evaluate the hypothesis that a statistically significant trend at Howland of increasing net C sequestration over the last 13 years is associated with decreases in ecosystem respiration.

- Continue our long running measurements of whole-ecosystem and soil CO_2 exchange (now in their 15th year), climate data and environmental drivers, and comprehensive suite of ecological factors. These data uncover new phenomena, provide information with which to test models and ground-truth satellite observations, and can identify changes in ecosystem response to climate; we will continue to archive data at CDIAC, ensuring its availability to the wider community.

- Investigate the relationships between CO_2 and CH_4 emissions in this mosaic landscape of moderately well drained and very poorly drained soils by carrying out whole-ecosystem CH_4 flux measurements.

The University of Maine's responsibility was to oversee and maintain various eddy covariance and climate measurement systems, carry out other ecological measurements, and operate and maintain the Howland field site including overseeing site safety.

Results

Howland Forest stores approximately 1.7 metric tons of carbon per hectare per year. Interannual differences can however be quite varied. The purpose of this project has been to continue critical CO_2 flux, meteorological and environmental measurements Howland Forest to help researchers better understand how variations in short-term climatic conditions affect the sequestration of carbon by the forest ecosystem.

All relevant CO_2 flux, methane flux, meteorological and environmental monitoring efforts continued at Howland Forest. There were no major malfunctions of any data acquisition systems and all operated continuously through the period.

During this period, biometric and tree mensuration data were remeasured on an established 3 hectare stem plot near the main tower and on established FIA transects associated with the main, west and east towers. LAI was remeasured each growing season on an established 20 point LAI transect north of the main tower.

Preliminary set up for isotopic carbon measurements and trapping began in the growing season of 2011. The early system consisted of a Picarro Isotopic Analyzer, standard gas, CO_2 scrubber, and a sample tube. Eastern Hemlock and Red Spruce roots were collected, weighed, and inserted into the sample tube for $\delta^{13}CO_2$ measurement. The sample tube was scrubbed of carbon before inserting the sample and leak-checked following each sample run. All root samples were oven dried and sent for analysis. Refinement of the trapping and measurement system was conducted during the winter of 2011 – 2012 and a new, improved system was developed. Monthly measurements of $\delta^{13}CO_2$ and $\delta^{14}CO_2$ trapping of tree roots (Eastern hemlock & Red spruce), root-free soil organic matter, and soil respiration chambers were conducted monthly each year (2012 – 2013) from spring through early fall. The soil respiration chambers are part of an on-going automated soil respiration system made up of six chambers – three of the chambers were trenched to exclude tree roots in the fall of 2012. All root and soil samples were weighed then placed in mason jars and flushed with CO_2-free air. Samples were allowed to incubate then measured using a Picarro Isotopic Analyzer. 13C measurements were also taken from the six automated soil respiration chambers attached to a Picarro Isotopic Analyzer. $\delta^{14}CO_2$ trapping was done using a trapping apparatus (liquid nitrogen method) attached to the mason jars containing the root and soil samples. Each of six soil respiration chambers were also connected to the trapping system and samples obtained. Dead air standard gas samples were trapped at each monthly session. Atmospheric carbon samples were obtained by growing chia seeds on the tower top. Plants were harvested every 2 – 3 weeks and oven dried. All samples were sent for $\delta^{14}CO_2$ analysis.

A test tree stem respiration system, with measurements of CO_2, $\delta^{13}CO_2$ isotopes, and water vapor in real time, was successfully installed and operated to further refine, partition and quantify ecosystem carbon exchange and cycling.

Site safety at Howland Forest is an important consideration. Continuous atmospheric and environmental measurements require specialized equipment and permanent infrastructure. Field work in the forest and outdoor elements throughout all seasons can present unique challenges. Safety procedures for Howland Forest operations were first established with the inception of the site. These protocols are regularly reviewed and have been modified and appended over time to refine and update certain procedures, and to encompass new research activities or new equipment safety issues. Before any work is conducted at Howland Forest, all new researchers, staff or students are given site specific and field safety training. Additional training is provided to those required to use specialized safety equipment (example: tower climbing). This document is posted next to the entry door of the field lab building.

These data have been delivered to Dr. Hollinger of USDA Forest Service and AmeriFlux. Real-time, regularly collected and appended data are available to the Forest Service and others or upon request for specific data sets.