Isotope ratio partitioning of ecosystem CO_2 fluxes to understand forest response to climate change: long-term measurements with novel instrumentation

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ABSTRACT

1. The objectives of this project are to:

a. Test the capability of a newly developed Quantum Cascade laser (QCL) absorption spectrometer to make the first continuous long-term eddy covariance measurements of the isotopic composition ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) of CO_2 fluxes in a forest, and to make frequent measurements of soil flux isotopic composition using chamber methods.
b. Partition net ecosystem exchange of CO_2 at Harvard Forest, MA, using isotopic methods;
c. Observe diurnal, seasonal and interannual variability in isotopic composition of fluxes and in whole-system photosynthesis and respiration (via two complete years of initial observations).

2. The science questions motivating this proposal are:

a. What are the separate controls on photosynthetic and respiration components of net ecosystem exchange of CO_2 in a temperate forest? This question is central to understanding carbon cycle feedbacks to climate. Isotopic methods can make an empirically-based separation, but application of these methods remains limited by measurement difficulties.
b. What is the relative ability of measurements of $^{13}C/^{12}C$ versus $^{18}O/^{16}O$ in CO_2 to achieve effective partitioning of net flux into photosynthetic and respiratory components? Better understanding of the potential advantages and disadvantages of using carbon versus oxygen isotopes to partition fluxes is needed, but continuous long-term datasets of both sets of isotopes, in concentrations and in fluxes, are needed.

3. Research site: eddy covariance flux tower site, Harvard Forest, Petersham, MA.

4. The methods are based on the fact that photosynthesis discriminates against $^{13}CO_2$ relative to $^{12}CO_2$, that there are differences in $^{18}O/^{16}O$ ratios in CO_2 fluxes from leaves versus in fluxes from soil. We will take advantage of the low-cost availability of a newly developed laser absorption spectrometer that can make continuous eddy covariance measurements of the isotopic composition of CO_2 fluxes ($^{13}C/^{12}C$ and $^{18}O/^{16}O$), enabling partitioning of photosynthetic and respiratory components of net CO_2 flux. The instrument will also be used to sample from soil chambers, acquiring isotopic composition of soil fluxes.

5. Science deliverables include **(a)** two years of hourly measurements of the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ composition of NEE and concentration profiles of CO_2; **(b)** an isotope-based partitioning of net CO_2 exchange into its biologically relevant photosynthetic and respiration components; **(c)** an assessment, via response to seasonal and interannual variability, of the separate controls on isotopically-derived photosynthesis and respiration fluxes, in order to better understand and predict the effects of climatic change on ecosystem-atmosphere carbon exchanges in this key ecosystem.