FEASIBILITY OF EDDY COVARIANCE MEASUREMENTS OF THE ISOTOPIC COMPOSITION OF CO_2 FLUXES ABOVE A FOREST ECOSYSTEM USING QUANTUM CASCADE LASER ABSORPTION SPECTROSCOPY

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ABSTRACT
Better quantification of atmosphere-ecosystem exchange of the isotopologues of CO_2 could substantially improve our ability to probe underlying physiological and ecological mechanisms controlling ecosystem carbon exchange, but the ability to make long-term continuous measurements of the isotopic composition of exchange fluxes has been limited by measurement difficulties. Quantum cascade (QC) lasers are a new generation of infrared light sources that offer increased stability and power for absorption spectroscopy applications (including the measurement of isotope ratios in atmospheric CO_2) and promise substantial improvements over existing instruments: smaller size, increased robustness, and most significantly for remote or long-term field deployments, no need for cryogenic cooling of laser or detectors.

We used simulations to test whether the performance of a prototype pulsed QC laser-based isotope-ratio absorption spectrometer (and plausible improvements thereon) is sufficient for making direct eddy covariance measurements of the $^{13}C/^{12}C$ isotope ratio of CO_2 fluxes above a mid-latitude temperate forest (Harvard Forest, in central Massachusetts, USA). We found that the measurement precision of a prototype instrument [~0.2 ‰, 1 SD of 10-sec integrations, see *McManus et al.*, 2005] gave simulated $^{13}C/^{12}C$ isoflux measurement errors of not more than ~1.5 to 2 times larger than the irreducible "meteorological" noise inherently associated with turbulent flux measurements above this ecosystem (daytime measurement error SD of ~60% of flux versus meteorological noise of 30-40% for instantaneous half-hour fluxes). Our analysis also shows that plausible instrument improvements (increase of precision to ~0.1 ‰, 1 SD of 10-sec integrations, and increased instrument stability during the 1-half hour needed to integrate eddy covariance measurements) should be able to reduce flux measurement errors to a level comparable to or less than the meteorological noise. This suggests that sensor error should not be a limiting factor in these measurements, and that continuous long-term observations of the isotopic composition of CO_2 fluxes via eddy covariance methods are feasible.

REFERENCES
McManus, J.B., D.D. Nelson, J.H. Shorter, R. Jimenez, S. Herndon, S. Saleska, and M.S. Zahniser, A high precision pulsed QCL spectrometer for measurements of stable isotopes of carbon dioxide, *J. Modern Optics*, in press, 2005.

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