

## NSF CAREER: Measurement and Modeling of Land-Atmosphere Isotopic CO<sub>2</sub> exchange in the Upper Midwest, United States

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The primary goal of this NSF-CAREER development plan is to improve the scientific understanding of the biophysical processes and discrimination mechanisms controlling the exchange of carbon dioxide (<sup>13</sup>CO<sub>2</sub> and <sup>12</sup>CO<sub>2</sub>) between the land and atmosphere at the ecosystem, landscape, and regional scales. This will be accomplished through the development of innovative research techniques and educational activities for undergraduate and graduate students in Land-Atmosphere Science (LAS) at the University of Minnesota. The research and teaching plan addresses an important mission of the NSF Lower Atmosphere Chemistry Section: To improve methods for measuring and modeling the concentrations of trace species and fluxes in and out of the atmosphere.

The objectives are to: 1) Develop and improve micrometeorological and boundary layer methods for measuring isotopic CO<sub>2</sub> fluxes at the ecosystem, landscape, and regional scales; 2) Quantify isotopic fluxes and key biophysical parameters ( $\delta_R$ ,  $\delta_N$ ,  $\Delta$ ) to help understand <sup>13</sup>CO<sub>2</sub> discrimination mechanisms; 3) Determine the extent, rate of change, and controls on isotopic disequilibrium within a heterogeneous region in the upper Midwest, United States; 4) Combine measurements and models to constrain key discrimination parameters at the ecosystem, landscape, and regional scales; and 5) Develop an intermediate level undergraduate course in LAS with a significant field component to provide exemplary learning opportunities for students at the University of Minnesota.

The methodological approach involves fast tunable diode laser (TDL) measurement of isotopomer mixing ratios, <sup>12</sup>CO<sub>2</sub> and <sup>13</sup>CO<sub>2</sub>, in combination with the eddy covariance approach for tall tower (244 m) isotopic flux measurements in a heterogeneous landscape. The Atmosphere-Land Exchange (ALEX) model will be used to simulate carbon fluxes and constrain <sup>13</sup>CO<sub>2</sub> discrimination processes/parameters at the ecosystem, landscape, and regional scales. The methodological approach is designed to provide an observational- and model-based framework for studying variations in atmospheric  $\delta^{13}\text{CO}_2$  caused by climate variation and land use change. Undergraduate research opportunities will be closely coupled to graduate research. Training activities will be provided in four broad areas: micrometeorological theory and techniques; stable isotope theory and techniques; data acquisition methods, and computer programming and modeling. An intermediate undergraduate course, Land-Atmosphere Interactions, will be developed and will include an intensive 2-week spring intersession field component. The aim is to bridge the knowledge gap between introductory and graduate level courses in LAS at the University of Minnesota, while including a strong practical component to reinforce theoretical knowledge and to foster student interest in land-atmosphere science at the graduate level.

With the help of this grant and through collaborative work with students and colleagues, significant contributions to the scientific community and the education of future scientists will be made. The broader impacts include: 1) Development of novel atmospheric measurement techniques for studying the impact of climate variation and land management on the atmospheric CO<sub>2</sub> content and composition; 2) Assessment of the carbon sink/source potential of large geographical regions dominated by land use change; 3) Acquisition of unique datasets, parameters, and algorithms to be shared with the scientific community (i.e. BASIN, AmeriFlux, Global FLUXNET); 4) Increased

national/international collaboration on carbon cycle science issues and integration of science and technical issues through private industry involvement; 5) Unique undergraduate, graduate, and postdoctoral research opportunities; 6) Development and enhancement of course materials for the LAS program; and 7) Increased visibility for atmospheric and global change issues through outreach efforts including collaboration with Minnesota Public Radio.