

## Project Summary

Magnitudes and future source/sink strengths of terrestrial ecosystem exchanges of carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) to the atmosphere are highly uncertain, subject to large interannual variability, and responsible for a long term trajectory of the atmospheric greenhouse effect. While CO<sub>2</sub> has been extensively studied over the past several decades, research on CH<sub>4</sub> has been less exhaustive, especially at regional scales and in mixed upland-lowland landscapes. Atmospheric CH<sub>4</sub> has tripled since pre-industrial times and is a potent greenhouse gas. Moreover, regional interaction and concurrent changes of CO<sub>2</sub> and CH<sub>4</sub> surface-atmosphere exchange across landscapes confounds predictions of future radiative climate forcing and atmospheric chemistry/air quality.

The **goal** of this CAREER proposal is to initiate a novel study of regional (10s-100s of km) CH<sub>4</sub> exchange and incorporate it into an existing study of regional CO<sub>2</sub> exchange in the upper Midwest, USA. A multi-year trend in rising temperature and declining water table elevation have been observed. To test hypotheses on the effects of these and other environmental changes (e.g., precipitation, solar radiation) on CH<sub>4</sub> and CO<sub>2</sub> fluxes, I **propose** to quantify the regional exchange of these fluxes at a tall tower in Wisconsin, analyze their environmental controls, and predict sensitivity of regional biogeochemical cycling to climate and land use change with a next generation biogeochemical model.

To quantify the fluxes, I intend to build the first long-term tall-tower regional observatory of CH<sub>4</sub> ecosystem-atmosphere flux using a mix of boundary-layer tracer profiles and continuous eddy covariance with recently developed CH<sub>4</sub> instrumentation, complementing existing CO<sub>2</sub> flux observations occurring at a 447-m tower in N. Wisconsin. The tower is in a sub-boreal landscape with numerous small wetlands interspersed among northern hardwood forests. Tower measurements, plot-level CH<sub>4</sub> measurements, and a regional network of water table and micrometeorological measurements in upland and lowlands will be used to investigate moisture, temperature, and land use controls of regional CO<sub>2</sub> and CH<sub>4</sub> exchange at the diurnal to interannual timescale as well as be integrated into a place-based education and outreach plan.

### Intellectual Merit

Studying the regional exchange of biologically-relevant trace gases straddles research in climate-relevant global flux/transport processes and ecologically-relevant local biogeochemical processes, and thus contains potential for significantly improving predictions of future carbon sources/sinks. Observing and modeling regional-scale surface-atmosphere exchange is difficult to do and consequently, has had only limited application, especially for CH<sub>4</sub>. The environmental and anthropogenic controls on regional land-atmosphere exchange are poorly understood. Synergistic effects of these controls from interaction among landscapes can only be observed at the regional scale. This proposal addresses some of these issues with a combined observational and modeling study that will produce the first long-term record of both regional CH<sub>4</sub> and CO<sub>2</sub> exchange, investigations of regional environmental controls on them, and impacts on regional atmospheric chemistry and global climate.

### Broader Impacts

Outreach activities are integral to this CAREER proposal and will be used to increase exposure of STEM disciplines and the local impacts of global change research to 1.) Native American community college students at the College of Menominee Nation via a 12 day global change summer program, 2.) high-school students and the general public in rural Wisconsin via hands-on activities and talks at a local field station, 3.) international undergraduate visitors from India as part of a recently initiated student lab exchange program at UW-Madison, and 4.) undergraduate non-science majors at the University of Wisconsin-Madison taking a global change class. A Ph.D. student will be recruited who is specifically interested in integration of education and research and therefore will participate in implementation of these activities of part of his or her graduate studies and professional development.