Title: Functioning of wetlands as a source of atmospheric methane: a multi-scale and multi-disciplinary approach

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Methane (CH_4) is an important greenhouse gas, twenty times more potent than CO_2, but atmospheric concentrations of CH_4 under future climate change are uncertain. This is in part because many climate-sensitive ecosystems release both CH_4 and carbon dioxide (CO_2) and it is unknown how these systems will partition future releases of carbon to the atmosphere. Ecosystem observations of CH_4 emissions lack mechanistic links to the processes that govern CH_4 efflux: microbial production, oxidation, upward transport by ebullition, and diffusional transport. Understanding these processes, and their interactions, is critical for prediction of biosphere feedbacks to climate change. We propose a multi-scale and multi-disciplinary study of the processes controlling ecosystem fluxes of CH_4 to the atmosphere and their responses to experimental warming and elevated atmospheric CO_2 concentration. Taking advantage of unique LLNL capabilities and expertise, we will provide a new observational perspective on the interacting processes that determine CH_4 flux to the atmosphere. While we will focus on wetlands, our results and methods will be broadly applicable for carbon source attribution and quantification of terrestrial and marine CH_4 processes.

Our overall goal is to determine how climate change affects the interacting processes that determine net CH_4 and CO_2 emissions from wetlands. This work will provide the quantitative process level information required to evaluate the physiochemical parameterizations of CH_4 fluxes from wetlands and integrate microbial community function into these descriptors. Measurements will take advantage of the DOE experimental site: Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE). This experimental site includes warming and elevated CO2 treatments that will be applied to a boreal peatland forest in northern Minnesota beginning in spring 2014.

Our specific objectives are to: **(1)** Link belowground C-sources and processes to atmospheric fluxes of CO_2 and CH_4 through natural abundance isotopic observations of ^{13}C and ^{2}H (IRMS) and ^{14}C (AMS); **(2)** Identify the key microbial species influencing CH_4 production and consumption using stable isotope probing (^{13}C-Chip-SIP and NanoSIMS), **(3)** Constrain ebullition rates with depth-profiles of noble gases dissolved in subsurface pore water (NGMS), and **(4)** Synthesize our findings with a biogeochemical box model to describe wetland response to warming and eCO_2.

Our proposed work will identify how key environmental factors force changes in CH_4 fluxes. This work will provide parameterizations for physical and chemical models describing the processes from the micro and molecular scales up to the ecosystem scale and address the need to incorporate descriptions of microbial community function into these physicochemical models. Our proposed integration of disciplines and scales will influence the interpretation and modeling of biospheric trace gas fluxes to the atmosphere.