High latitude peatlands contain nearly half of Earth's soil carbon pool and represent a particularly significant terrestrial carbon sink. As result of their anoxic conditions, peatlands are simultaneously a large C sink but also a major source of CH_4 to the atmosphere. The greatest rates of warming are occurring at high latitudes and warming is predicted to accelerate the loss of the C stored in peat as a result of faster rates of decomposition. The magnitude of forms of these C losses as CO_2 and CH_4 remains highly uncertain.

To address these uncertainties we have proposed a measurement and modeling activity for the DOE-funded *Spruce and Peatland Response Under Climatic and Environmental Change* (SPRUCE) experiment in the Marcell Experimental Forest, MN. The field-based measurement activity will test four empirical hypotheses (EH) relating CO_2 and CH_4 emissions to experimental warming (0 to +9 ^{o}C in 2.25 ^{o}C increments) and elevated CO_2 (~850ppm):

EH1: Biogenic emissions of CO_2 and CH_4 will increase significantly at eCO_2 compared to aCO_2.

EH2: The rate of acetoclastic methanogensis relative to hydrogenotrophic methanogenesis will increase across the gradient in warming.

EH3: Reductions in water table height increase the depth of the aerobic layer thereby decreasing the rate of net methanogenesis and the CO_2-to-CH_4 ratio of emissions from the peat surface.

EH4: Elevated CO_2 significantly increases autotrophic and heterotrophic respiration in proportion to the level of experimental warming and compared to that observed at ambient CO_2.

The modeling activity will relate the field measurements to two modeling hypotheses that are relevant to identifying essential attributes of next generation ecosystem and earth system models: (1) models need explicit representation of agents (microbes and/or enzymes), environment (e.g., temperature and moisture), and substrate supply (including substrate diffusion) to skillfully simulate decomposition and heterotrophic respiration at any spatial or temporal scale; (2) because O_2 diffusion and consumption in soil drive aerobic and anaerobic microbial respiration, it should be possible to simulate both CO_2 and CH_4 fluxes simultaneously using the same soil physics model structure and carbon availability. The proposed data-model integration can also identify the types of observations needed to improve model parameterization, thus coupling *mod*eling with observational and *ex*perimental measurements (i.e., *ModEx*). This poster will present initial field results and the formulation of our modeling platform.