Title: **Simulations of Duke and Oak Ridge FACE Experiments with ELM-FATES-CNP**

Anthony Walker,[1]* Ryan Knox,[2] Charlie Koven,[2] Daniel Ricciuto,[1] Xinyuan Wei,[1] Xiaojuan Yang,[1]

[1]Oak Ridge National Laboratory, Oak Ridge, TN;
[2]Lawrence Berkley National Laboratory, Berkley, CA;

Contact: (walkerap@ornl.gov)

Project Lead Principal Investigator (PI): Anthony Walker

BER Program: ESS

Project: Free Air CO_2 Enrichment Model Data Synthesis (FACE-MDS) (DOE Lab-led project)

Project Website: https://facedata.ornl.gov/facemds

Project Abstract: The response of temperate forests to elevated atmospheric CO_2 (eCO2) can be constrained by the short-term dynamics of nitrogen (N) availability, which can interact with longer-term demographic processes. Understanding the interactions of N availability with forest growth processes as N is locked away in plant biomass and soils and then released as plants die and soils decay is necessary to develop predictive understanding of forest ecosystem responses to eCO2 at climate-change relevant timescales (i.e. decades). Long-term Free Air CO_2 Enrichment (FACE) experiments, such as Duke and Oak Ridge, ran for a single decade, providing information on eCO2, N, and demographic process interactions. We use these data to constrain simulations by the Functionally Assembled Terrestrial Ecosystem Simulator (FATES), a model with tree-size and time since disturbance resolution, embedded within the ELM land surface and terrestrial biosphere model. A model with a representation of size structure allows us to evaluate how size-structure and demographic processes may have influenced results at the Duke and ORNL FACE experiments, asking the question: How have demographic processes shaped the responses to eCO2 observed at long-term FACE experiments? Recent developments to bring nutrient cycling into ELM-FATES (ELM-FATES-CNP) now provide the N and other nutrient-related constraints within the model to simulate and evaluate eCO2, N, and demographic process interactions. In this spark presentation, we apply ELM-FATES-CNP to simulating the Duke and Oak Ridge FACE experiments. We use a C-only version of the model alongside two soil nutrient cycling hypotheses or conceptualizations that currently exist in ELM—relative demand and equilibrium chemistry approximation—modified to represent a dynamic allocation scheme that is more consistent with the data. Here we show that ELM-FATES-CNP can reproduce baseline, ambient treatment values of key ecosystem variables. eCO2 responses can depend on N dynamics but the magnitude of the N constraint is highly dependent on the V_{max} parameter values for N uptake. We also begin to investigate stand structure dynamics showing that the simulation

of a plantation forest and forest-structure more broadly is highly dependent on the specific assumptions made regarding crown, leaf, and sapwood allometry.