Abstract Title: Measurements and modeling of CO_2 concentration and isotopes to improve process-level understanding of Arctic and boreal carbon cycling

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This project seeks to understand terrestrial ecosystem processes that control the exchanges of CO_2 with the atmosphere on decadal and longer time scales. The approach involves carrying out time series measurements of CO_2 concentration and isotopes and uses these and other datasets to challenge and improve carbon cycle models, including earth system models. A core activity involves continuing measurements of CO_2 concentrations and isotopes from the Scripps CO_2 program from flasks collected at an array of ten stations distributed from the Arctic to the Antarctic. It also involves modeling studies and interpretive work to expand on the recent discovery based on airborne data that the amplitude of the seasonal cycle is cycle has increased by 50 to 60% since 1960 at latitudes north of 40N. This amplitude increase stands out as perhaps the most compelling evidence to date for wide-spread changes in land carbon cycling relevant for global CO_2 balance and climate change. This project focuses on three key questions: 1) How is the amplitude increase related to changes in net carbon flux in boreal and arctic systems? 2) What processes are responsible for the amplitude increase? 3) How can the models be improved to incorporate the relevant processes?

RESULTS: As modeling work in support of this project is at early stages, emphasis will be placed on observational results. Updates will be presented of seasonal amplitudes at benchmark stations, including Barrow, Alaska, and Mauna Loa as well as correlation between amplitude trends and climate indices. At Barrow, where large (~35%) amplitude increases since 1960 were reported by Graven et al. (Science, 2013), the seasonal amplitude has remained fairly steady over the past 5 years, roughly matching the record values achieved around 2010, and reinforcing the evidence for large long-term change. Updated results will also be presented on covariation of the seasonal cycles of atmospheric CO_2 and the $^{13}C/^{12}C$ ratio of CO_2 in the northern extratropics. This covariation can be used to assess large-scale trends leaf-level intrinsic water use efficiency (iWUE) and changes in ratio of CO_2 partial pressure within leaf (Ci) compared to the free atmosphere (Ca), and is an important constraint on the causes of the long-term trends in amplitude and land biospheric productivity.