Large-scale shifts in land metabolic activity indicated by changing seasonal cycle of atmospheric CO_2

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PROJECT OBJECTIVES: This project has the overall goal of producing datasets of atmospheric CO_2 and its isotopes relevant for documenting changes in the global carbon cycle and improving understanding of how land ecosystems may influence and be influenced by future CO_2 and climate changes. It also has a more focused goal of using these and other data to challenge models that depict the response of changing climate and human forcing (e.g. rising CO_2) on northern extra-tropical ecosystems over multi-decadal time scales, using records extended over the past 50 years.

RESULTS: An important result was the study of Graven et al. (Nature, 2013) documenting a large increase in the amplitude of atmospheric concentration seen in airborne and surface data at high northern latitudes from 1960 to 2010. The amplitude trends were found to be of order 50% north of 45°N, but much smaller south of 45N. The amplitude increase evidently requires an increase in summer-time NPP of order 50% focused on boreal forests. Further ongoing work shows that the amplitude at Mauna Loa shows large quasi-decadal variability, which correlates well with the Pacific Decadal Oscillation (PDO) Index, probably in large part owing to changes in water status of western and middle North America that correlate with the PDO. An overall rise at Mauna Loa amplitude of around 15% is not explained, however, by the PDO. The pattern revealed by airborne and ground-based CO_2 data may require both large long-term increases in NPP north of 45°N, and also small reductions in the seasonal CO_2 exchange at lower latitudes.

Additional ongoing work relates to the changing covariation of the seasonal cycles of atmospheric CO_2 and the 13C/12C ratio of CO_2 in the northern extratropics. This data 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). The conventional wisdom has been that the Ci/Ca ratio of would remain approximately constant as CO_2 rises, which would result in no change in discrimination but a modest increase in water-use efficiency. The atmospheric data are generally consistent with a constant Ca-Ci scenario, which increases discrimination, but corresponds to a constant iWUE. The atmospheric data are not easily reconciled with the study Keenan et al. (Nature, 2013) who suggested based on FluxNet data that a large increase in iWUE has occurred in recent decades.