Potential New Methods for Examining Regional Sources and Sinks of Carbon

E. Weatherhead[1], P. Tans[2], L. Bruhwiler[2], C. Sweeney[1] and J. Maslanik[3]

[1]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309; 303-497-6653, E-mail: betsy.weatherhead@colorado.edu
[2]NOAA Earth System Research Laboratory, Boulder, CO 80305
[3]University of Colorado, Boulder, CO 80309

Unmanned Aircraft Systems (UAS) offer unique capabilities for measuring carbon fluxes over regions critical for carbon cycle research. In a pre-programmed mode, the vehicles can fly repeat patterns over varying time periods to measure diurnal, seasonal and annual variability in fluxes. Four specific science objectives that UAS could address would include: 1) Quantify ecosystem fluxes and variability; 2) Distinguish locally produced sub-grid variability of CO_2, CH_4 mole fraction from patterns advected from outside control region; 3) Scale-up ecosystem flux measurements to 10,000 km^2 and 4) Compare flux estimates from models and satellite retrievals with *in situ* observations. The ability to address these questions would provide an important link between the current satellite, modeling and measurement communities and could offer results to clarify the discrepancies in estimates of regional fluxes.

Aircraft have been used to estimate carbon fluxes, but questions remain as to the amount of disturbance introduced by the airplane and the ability to distinguish between ambient vertical air motion from that induced by the vehicle. UASs preserve the flexibility of manned aircraft and offer two distinct advantages: they can fly lower and with less disturbance to ambient air movement. Using a combination of LICOR and Picarro gas analyzing instrumentation, we could resolve typical fluxes to an uncertainty of +/- 10%: CO_2 0.2 µmol m^{-2} s^{-1} (200 mg C m^{-2} day^{-1}) and CH_4 2 nmol m^{-2} s^{-1} (2.8 mg CH_4 m^{-2} day^{-1}). Combined with global positioning system-assisted location and attitude sensors we should be able to detect 1 km average fluxes every 100m and georectify these fluxes to surface conditions and spatial variabilities.

Uncertainty in fluxes due to advection could be quantified with transecting flights, both upwind and downwind of flux towers, to measure the amount of advected carbon not accounted for. Both the magnitude and sign of the flux varies through a 24-hr period resulting in large uncertainties on diurnal behavior of fluxes from tall towers and Eddy Covariance. Flux measurements over regions with existing flux towers will allow for identification of sub-grid variability that can influence existing flux algorithms. The primary test will be to determine if sub-grid flux characteristics can be approximated as linear.

Six locations stand out as particularly appropriate: Park Falls, WI and Lamont, OK are Total Carbon Column Observing Network primary validation sites, Fort Hunter Liggett, CA is a controlled burn site, Larimore, ND is in agricultural and Atqasuk and Tanana Valley are in separate parts of Alaska.

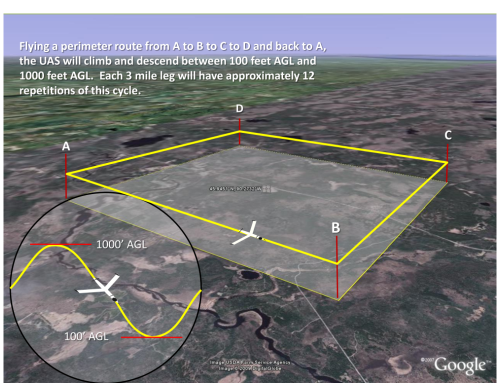

Figure 1. Regularly repeated flight plans will allow for a time series of carbon flux estimates across time scales that has previously not been possible.

Figure 2. Unmanned aircraft are serving a variety of societal and scientific roles--filling gaps that could not be filled with manned aircraft.