AIRCRAFT TO INVENTORES: A MULTISCALED INVESTIGATION OF CARBON FLUXES IN A MONTANE LANDSCAPE

David Schimel[1], Britton Stephens[1], Russell Monson[2], William Sacks[1], Jielun Sun[1] and ACME Science Team.

[1]National Center for Atmospheric Research, 1850 Table Mesa Drive, Boulder Colorado 80305
schimel@ucar.edu

University of Colorado, Boulder Colorado 80309-0334, monsonr@colorado.edu

As a result of landuse, 50% or more of forests in the Northern Hemisphere mid-latitudes are in hilly to mountainous terrain, accounting for half or more of the mid-latitude Gross Primary Productivity. The mid-latitude sink observed in the atmosphere may reflect carbon dynamics occurring in complex terrain. This is challenging: these regions are inherently highly heterogeneous and currently reflect complex land use histories, and atmospheric techniques for estimating spatially integrated carbon fluxes don't work well in sloping terrain. Consequently, the impacts of climate, harvesting regimes, disturbances and fire/pest management on carbon exchange are poorly constrained in mountains. While mountains are heterogeneous, the orientation of slopes to incident radiation and gravitational flows of air and water result in organization of the variability that can be exploited. Analysis using model-data fusion techniques of long-term eddy covariance data showed 1) mid-aged Rocky Mountain forests are sinks, 2) most of the net uptake occurs in the spring when melting snow provides moisture for photosynthesis but low soil temperatures inhibit respiration and 3) interannual variability is mainly due to GEE and is largely driven by spring temperature and precipitation, which both determine spring fluxes and set the stage for mid-summer soil moisture conditions.

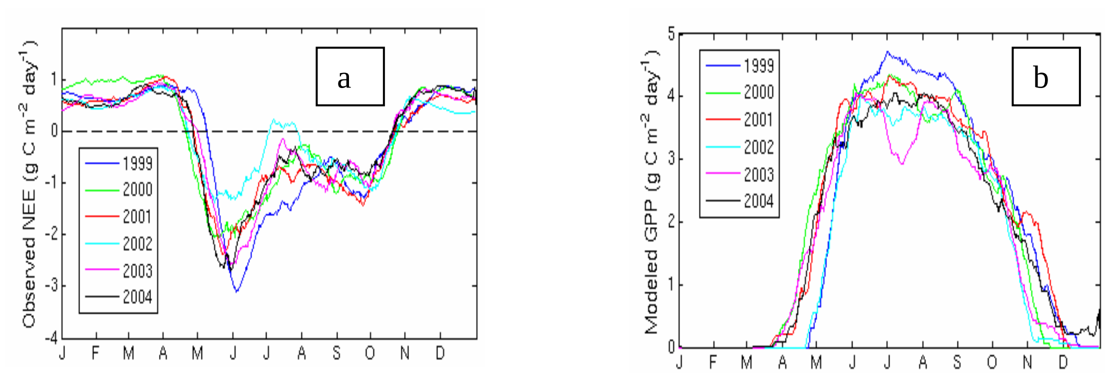

Fig. 1. Net Ecosystem Exchange at Niwot Ridge for 1999 (a) and Gross Primary Productivity (b), estimated from NEE using a carbon assimilation model.

In 2004, airborne and ground-based intensives were conducted to "scale" this knowledge to watersheds and the region. Daytime airborne boundary layer budgets in Colorado allowed extrapolation of local fluxes, allowing evaluation of the sign, magnitude and seasonality of the flux at large scale.

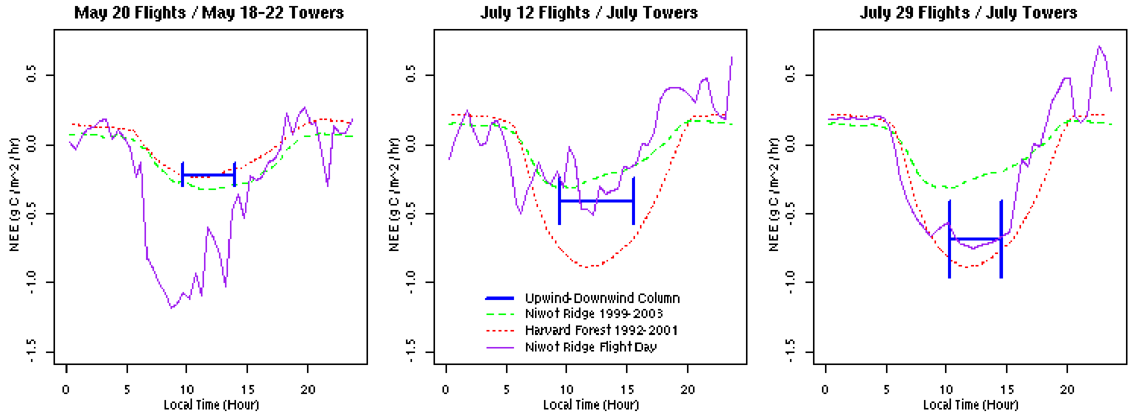

Fig. 2. Comparison of preliminary surface eddy covariance and airborne boundary layer budget fluxes. The lines indicate the actual daily flux at Niwot, climatological flux and, for comparison, fluxes at the Harvard Forest for an upper bound. The bars indicate the aircraft-estimated flux for the hours actually flown.

The surface-airborne fluxes showed remarkable agreement in mid-summer, but disagreed in the spring. This may be due to the regional variability of fluxes, with the tower being more representative in the later season, or it may be due to meteorological conditions. Surface measurement arrays consistently showed that respired CO_2 accumulating in the nocturnal boundary layer and flowing downslope, providing a large-scale constraint on this flux. During routine vertical profiling on the upwind boundary of the region, we discovered that the downslope flows of CO_2 observed by the tower array created nighttime "lakes" of CO_2 in Colorado's intermountain valleys that could be observed by aircraft in the morning. The magnitude of this enrichment and its persistence well into mid-morning were unexpected. These nighttime accumulations may be inverted to provide a constraint on respiration, the most poorly understood ecosystem flux, at the 103 km^2 scale. Multiscale observations guided by ecological and atmospheric principles, and integrated with assimilation models, can quantify the magnitude and controls over regional carbon dynamics. Organized mountains flows allow measurements of respiratory flux components at scales that are inaccessible in seemingly simpler landscapes.