Proposal for a FLUXNET Synthesis paper

Title:

LAI influence on bias in night time eddy covariance data during windy conditions

Outline:

Many studies find that eddy covariance measurements are lower than chamber-based estimates although large uncertainties associated with scaling up often prevent distinction between measurements. Even in a very simple annual grass system where measurement precision was maximized, a distinction based on instantaneous data was often difficult. However, results from this system showed that with greater LAI, eddy covariance estimates became increasingly underestimated relative to chamber-based estimates during windy conditions at night (Myklebust, unpublished data). Using FLUXNET data, Misson et al. (2007) showed that within-canopy air movement at night was affected by overstory LAI in windy conditions. This suggests that above-canopy measurements of CO_2 flux may depend both on respiration and LAI. If this relationship is generally true across ecosystems, this bias has implications when comparing eddy flux estimates across ecosystems of dissimilar LAI. We would like to use the Fluxnet database to test the hypothesis that during windy conditions at night, the underestimate of eddy covariance measurements relative to chamber-based estimate means of ecosystem respiration increases with LAI. Variables required for this study include: eddy covariance and micrometeorological measurements, canopy profile measurements of CO_2, LAI, and chamber or model-based estimates of ecosystem respiration. Representatives from each site that we use in the analyses will be included as co-authors in publications resulting from this work.

A potential complication of this relationship is that topography may influence advection in a site specific manner (Feigenwinter, et al., in press). To address these effects, we would like to explore potential spatial indices derived from digital topographical maps that may characterize the topographical complexity of each site as a proxy for how much each site is 'prone' to advection.

Although we have data that strongly suggests bias in night time eddy covariance measurements, they cannot provide a mechanism for our findings. It is possible that during windy conditions at night, canopy air was only periodically flushed out in short bursts but otherwise, was trapped in the canopy. The resulting series of half-hourly averages of flux data would show mainly low values with intermittent spikes. Wohlfahrt et al. (2005) suggested that some data spikes that are normally removed during the eddy covariance data cleaning process represent periods when air is flushed out of the canopy. In that case, removing these spikes would cause underestimation of ecosystem respiration. Wohlfahrt et al. (2005) presented a procedure to identify spikes that may represent actual fluxes but were unable to state conclusively whether the spikes should or should not be left in due to large uncertainties in estimates at their site. We would like to re-analyze eddy covariance data from a number of sites of varying LAI and structure to see how the inclusion of spikes may improve the agreement between eddy covariance and chamber-based estimate means of night-time ecosystem respiration.

If canopy air is only periodically flushed out of the canopy on windy nights, gradients of temperature and CO_2 in canopy air profiles should become neutral as spikes in eddy flux data

are recorded. We have the opportunity to make observations of canopy air profiles and flux readings at the top of the canopy at Fontblanche, a site that is currently being instrumented. This site is a Mediterranean pine-oak forest subject to 'le Mistral', a strong wind that blows across the area for one to several days (and importantly, for several nights) in a row. Current theory predicts that these conditions are adequate for eddy covariance measurements of night-time ecosystem respiration. Therefore, we can expect to have sufficient data over the coming months that can be used to investigate whether the mechanism of intermittent transport of canopy air, proposed by Wohlfahrt et al. (2005), has support.

In summary, we want to investigate whether a general relationship of underestimation of night-time eddy covariance data and LAI is present across ecosystems. Further, we want to investigate a possible mechanism for this underestimation by an alternative data processing procedure and by direct measurement. The intent of this investigation is to identify and correct a possible bias in eddy covariance-based estimates of night-time ecosystem respiration.

References:

Feigenwinter, C., Bernhofer, C., Eichelmann, U. Comparison of horizontal and vertical advective CO_2 fluxes at three forest sites. Agricultural and Forest Meteorology, *in press*.

Misson, L. Baldocchi, D.D., Black, T.A., et al., 2007. Partitioning forest carbon fluxes with overstory and understory eddy-covariance measurements: a synthesis based on FLUXNET data. Agricultural and Forest Meteorology 144, 14-31.

Wohlfahrt G., Afgang, C., Bahn, M., et al., 2005. Quantifying nighttime ecosystem respiration of a meadow using eddy covariance, chambers and modeling. Agricultural and Forest Meteorology 128, 141-162.

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