Quantifying the value of long-term flux tower observations: Is a decade better than a few years?

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Abstract

It is likely that climate-carbon cycle feedbacks in temperate forests are mediated both by internal ecosystem-climate forcing on interannual to decadal scales and longer-term anthorpogenic perturbations to the state of the forest. Here we demonstrate how long-term flux tower data and long-term models of forest harvest can both provide insight on these processes.

Introduction:

The WLEF Park Falls, WI Ameriflux site has observed very tall tower regional carbon fluxes since 1997 in a northern temperate mixed forest and wetland landscape (Fig 1).

We can remove the long-term ensemble average flux signal to make a stronger test of how anomalies in net photosynthetic night minus day drawdown (Pd), derived from net ecosystem exchange of CO2 (NEE), are functions of other variables.

Here we test two hypotheses: one on internal (carbon storage) control and one on moisture control. Running mean averaging filters and lag correlations were applied to all variables over the 15 year period. Prior to this analysis, ensemble mean was removed, and anomalies were normalized (Fig 2). Further statistics for significance were applied after accounting for inherent autocorrelation of flux tower time series, reducing degrees of freedom by several orders of magnitude, and looking for regions where lagged correlation with Pd exceed autocorrelation of Pd to falsify the first hypothesis.

Results:

Significant positive autocorrelations of (Pd) exist at the -1 to -3 lags up to seasonal timescales (Fig 3a). Interestingly, none of these features are well explained by remotely sensed vegetation index MODIS EVI except for weekly averaging at one month lag (Fig 3b).

Moisture variables are generally positive correlated with Pd, but only weakly predict Pd. Previous two or three month precipitation (Fig. 4a) and soil moisture (Fig. 4b) has a greater correlation to Pd than autocorrelation at weekly to seasonal averaging timescale.

Conclusions:

Significant predictive power exist in lagged Pd that suggest short, but not long, timescale carbon storage mechanisms can predict future Pd out to one month.

These are superimposed by longer term predictive power for precipitation and soil moisture on Pd, consistent with earlier work showing that soil moisture is related to interannual variability of NEE at this site.

Further analysis is ongoing to understand how to use these analyses in a data assimilation framework.

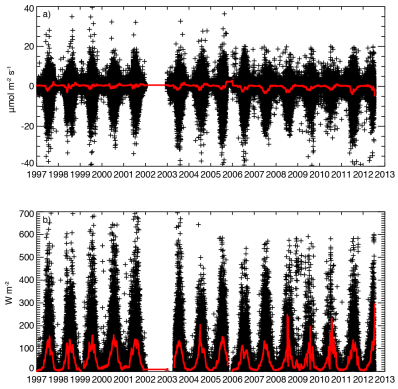

Fig. 1 Nearly fifteen year time series a) net ecosystem exchange of CO2 and b) evapotranspiration flux at hourly (black crosses) and biweekly (red line) timescales as observed from the WLEF Park Falls, WI very tall eddy covariance flux tower from 1997-2012.

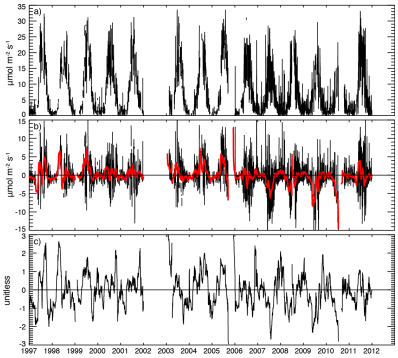

Fig 2. Example of generating relative anomalies for lag correlation analysis. Raw daily time series of (a) net photosynthetic drawdown are (b) de-seasonalized by removal of the ensemble average daily timeseries and then averaged to the appropriate averaging timescale, in this example, monthly (red line) and finally (c) normalized to relative values. The final signal represents the true anoamlies of variation across time and has successful removal of the seasonal variability of solar forcing.

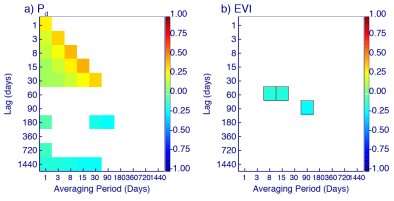

Fig 3. Correlation of photosynthetic night to day drawdown (Pd) to (a) itself and (b) remotely sensed EVI at a range of lags and averaging timescales. Only those correlations that are significant, after removal of long-term seasonal cycle and correction for degrees of freedom are shown. Red boxes in (b) indicate significant correlation that exceed autocorrelation with Pd.

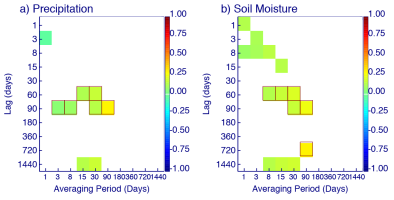

Fig 4. (a) precipitation and (b) soil moisture relationships to Pd.

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