Is the underestimate of ecosystem respiration measured by eddy covariance related to LAI?

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Introduction

Nocturnal measurements of ecosystem respiration by eddy covariance (EC) are often lower than estimates made by alternative methods (Reco). Even in turbulent conditions, a high leaf area index (LAI) may prevent turbulence from reaching the lowest layer of the canopy and reduce the amount of flux detected by the sensors (Yi, 2008). This study looks at the effect of LAI on the underestimate of EC measurements of ecosystem respiration by the agreement with Reco.

Objectives

1. Establish that eddy covariance measurements estimate ecosystem respiration accurately in zero LAI over a very simple surface.
2. Establish that eddy covariance underestimates ecosystem respiration as LAI increases at the same site.
3. Test to see if LAI is correlated to underestimate of LAI across a range of different LAI and vegetation structures.

Methods: simple surface

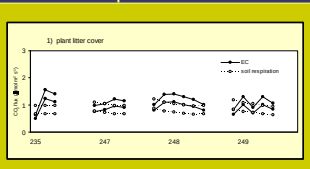
Terrain: Flat
Vegetation: *Bromus tectorum* annual grass
Soils: fine sandy loam
Surface: snow
live grass
grass litter



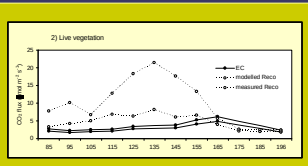

Eddy covariance (EC): Turbulence fluxes of CO_2 were determined from measurements using a CSAT 3D sonic anemometer and LI-7500 gas analyzer mounted 2 m above the surface and sampled at 10 Hz. A u* threshold of 0.6 m s^{-1} was used at night. Similar results were obtained using a threshold of 0.3 m s^{-1}. Footprint analysis confirmed that fluxes measured were from the surface of interest.

Ecosystem respiration (Reco): Canopy and soil respiration components were estimated by:
1. Bi-weekly measurements of leaf CO_2 exchange once every three hours for a 24-hour period.
2. Modeled canopy respiration based on gross photosynthesis estimates.
3. Measured soil respiration using the gradient (Tang et al. 2003) and chamber methods.

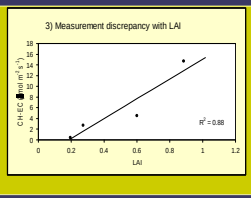
Results: simple surface



EC and Reco showed agreement when the soil was covered in plant litter (fig. 1) but there was disagreement between when it was covered with living vegetation (fig. 2).

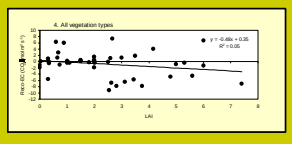


The magnitude of disagreement between Reco and EC showed a positive relationship with LAI (fig. 3).

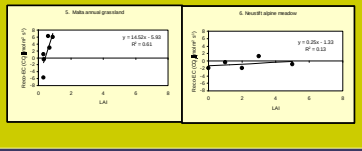


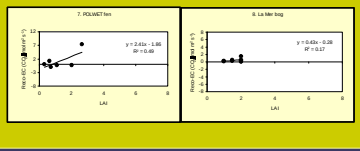
Methods and Preliminary Results over variety of surfaces

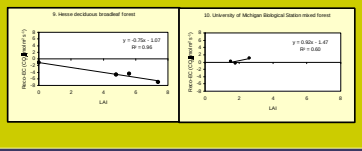
Thirteen sites representing a variety of vegetation structures and LAI values have contributed nocturnal eddy covariance (EC) and EC-independent ecosystem respiration (Reco) data.
No simple global relationship between Reco and EC with LAI has been detected (fig 4).

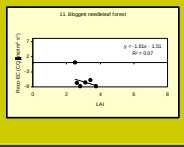


Seven sites have a range of LAI either intra- or inter-annually. Preliminary data shows the relationship between average difference between Reco and EC varies with LAI but the relationship may be positive of negative (figs 5-12).









Future work

The relationship of LAI with the difference between EC relative to Reco is complex.
Further work will investigate the effect of canopy structure and topography.

References

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