THE ROLE OF CANOPY ARCHITECTURE ON GROSS ECOSYSTEM PRODUCTION RESPONSES TO DIFFUSE LIGHT.

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Proposed FLUXNET Synthesis Publication outline

Introduction and objectives:

Since the inception of long-term, high-frequency eddy covariance observations of net ecosystem exchange of CO_2 (NEE), studies began linking the presence of clouds or other atmospheric aerosols with enhanced levels of ecosystem net CO_2 uptake (e.g. Price and Black 1990, Hollinger et al. 1994, Fitzjarrald et al. 1998, Gu et al. 1999, 2002, Oliphant et al. 2002, Letts et al. 2005, Misson et al. 2005). This effect has now been noted in several different ecosystems, although appears to be most pronounced in tall, multi-layered broadleaf forests (Gu et al. 2002).

Although not well understood at the mechanistic level, a compelling argument to explain the enhanced productivity is the more photosynthetically effective distribution of light within the canopy when down-welling incident photosynthetically active radiation (PAR) is multi-directional or diffuse beam (PAR_D). Comparison of the relatively scarce published research that directly addresses this PAR_D: NEE effect supports the idea that canopy architectural differences may account for the some of the variability in magnitude of enhanced productivity under diffuse PAR conditions observed in the bio-micrometeorology community. Investigation of the vertical distribution of PAR within a tall deciduous forest canopy under different levels of diffuse PAR also supports this theory (Oliphant et al. 2006). In order to tease out the importance of canopy architecture on the role of PAR_D on ecosystem productivity, further research needs to focus on large scale inter-site comparisons as well as further detailed site specific experimental research on light and leaf area distributions.

The objective of the proposed research is to investigate the role of ecosystem canopy architecture on the enhancement of NEE under optimal PAR_D conditions by comparing the strength and magnitude of the ecosystem production response for a wide range of canopy architectural types from short grasses to tall and dense forests. This can be accomplished using standardized methods and datasets in collaboration with the FLUXNET community.

Data and methods:

The criteria used to select from available FLUXNET sites for this comparison include;

- Sites that are relatively horizontally homogeneous in canopy architecture to avoid mixing signals in patchy vegetation, woody savannahs etc. This would include most sites in IGBP classes; closed shrublands, needleleaf (evergreens and deciduous), broadleaf (evergreen and deciduous), savannahs, grasslands, and many croplands and mixed forests.
- Sites from multiple continents and a range of biomes and climate groups.
- Multiple sites with similar canopy architectures.
- Site data must have a minimum temporal frequency of 60 minutes (30-minutes preferred) and should contain at least one year in duration.

For analysis these sites will be grouped into five to ten canopy classes. The exact class breakdown will depend on the number and type of available sites, but will be based on characteristic features of the vertical LAI profile for each site, such as depth, leaf density, vertical distribution of leaf density (presence of multiple layers etc). The LAI profiles will be approximated from available site metadata if data are not available.

Individual site analysis will include the estimation of PAR_D/PAR_G (PAR_G is global PAR) for each measurement period using site radiometers (global solar radiation or PAR_G will suffice). Any available diffuse radiometer data will be used for direct estimation of the diffuse component and/or to locally tune the relation between PAR_D/PAR_G and indices generated from global radiation data (Oliphant et al 2006). Secondly, optimal scattering conditions for NEE as well as strength of the response signal for each site will be calculated using the method by Gu et al. (1999) and magnitudes of the enhancement from Oliphant et al. (2002) as well as the slope and position of the site light use efficiency curve under different levels of scattering (Oliphant et al 2006).

The characteristics of ecosystem production response to diffuse light generated for each site as outlined above will then be stratified by canopy architectural groups. From this synthetic analysis, the degree to which the PAR_D:NEE response of canopy groups are statistically different from one another will be tested as well as the magnitude and sign of the differences. This will help inform whether canopy structure plays a significant role in the PAR_D:NEE relation and if so, produce separate parametric models for each canopy class.

Significance:

The research is important because the magnitude of enhancements in productivity under optimal diffuse light conditions are considerable (~25%, Oliphant et al 2002) and has been observed to affect global scale CO_2 concentrations following large low-latitude volcanic eruptions (Gu et al. 2003, Krakauer and Randerson 2003). Change in cloud and aerosol characteristics is thereby likely to cause a significant ecosystem and carbon cycle response, which in the case of CO_2 forced climate change may present an important feedback mechanism in the climate system.

References:

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Co-authorship strategy

Once the available sites have been screened to meet the requirements of this study, the PIs of the sites selected for analysis will be contacted to offer co-authorship, discuss the research ideas and seek clarification of or additional site metadata, particularly on canopy structure. Once co-authorship is established I will maintain communication with co-authors throughout the process soliciting ideas, revision and discussion. I am not aware of but imagine there is other work proposed on this topic and I would welcome collaboration and don't mind shifting my focus to accommodate.

From reading the RFP, it seems I would not be eligible to use the data until May 2008 since I am only indirectly related to the MMSF FLUXNET site and therefore not a contributor. This would be fine as I am planning to finish a methodological study on this topic using MMSF data and designed for use in the proposed project. In this case the proposed project timeline would be May 2008-May 2009.