A Promising Remote Sensing Approach for Mapping Ecosystem Carbon Sequestration

A. F. Rahman (Ball State University,765-285-1172, faiz@bsu.edu), **D. A. Sims**

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Data From NorthEast Area

PROBLEM STATEMENT

Most current models that are used to estimate ecosystem carbon fluxes (either Gross Primary Productivity, GPP, or Net Primary Productivity, NPP) are complex and require a large number of input parameters that are generally not available at regional or continental scales. For example, the global GPP and NPP products based on Moderate Resolution Imaging Spectroradiometer (MODIS) imagery are expressed as follows:

$$GPP = (SW_{rad} \times 0.45 \times F_{PAR}) \times \{\varepsilon_{\max} \times f(VPD) \times f(T_{\min})\}$$

$$NPP = \sum_{1}^{365} GPP - (R_m + R_g)$$

SW_{rad} = Short wave radiation

F_{PAR} = Fraction of photosynthetically active radiation

ε_{max} = Maximum light use efficiency of a vegetation type

VPD = Vapor pressure deficit

T_{min} = Minimum temperature

R_m = Maintenance respiration

R_g = Growth respiration

It is unrealistic to obtain these parameter values from each and every terrestrial pixel. Look-up tables are generally used to run these models and as a result, the output of these complex models may not be able to correctly estimate the carbon uptake of different vegetation types.

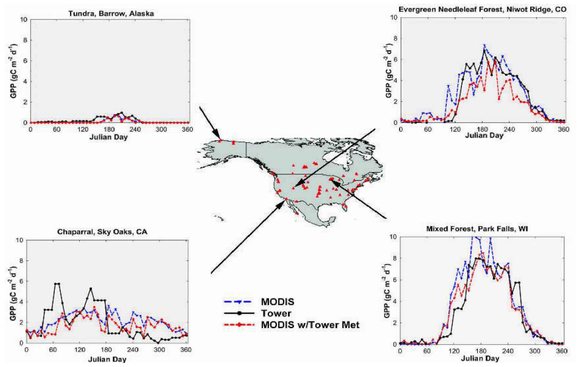
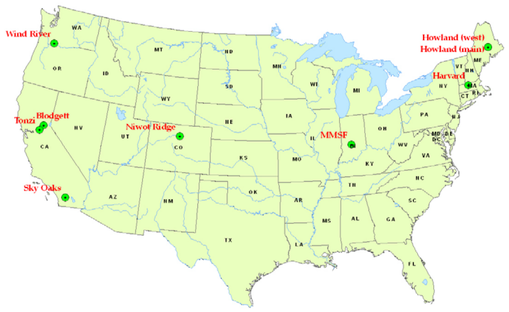


Figure: Intercomparison of GPP computed from daily MODIS data summed at 8-day intervals with GPP measurements from flux towers at sites in the AmeriFlux network that represent different biomes and climatic regimes for 2001. These figures show the mismatch between MODIS estimates and ground-based observations (Reference: Running et al., BioScience, June 2004 / Vol. 54 No. 6, pages 547-560)

OUR APPROACH

We have been exploring the possibility that both photosynthesis and respiration fluxes can be estimated directly from satellite remote sensing using spectral reflectance indices. In this study we compare the 16 day MODIS composite values of normalized difference vegetation index (NDVI) and the enhanced vegetation index (EVI) to carbon flux data from eight AmeriFlux eddy covariance tower sites:



Blodgett	Evergreen needleleaf
Niwot Ridge	Evergreen needleleaf
Howland forest	Evergreen needleleaf
Harvard forest	Deciduous broadleaf
Morgan Monroe	Deciduous broadleaf
Sky Oaks	Semiarid Shrubland
Wind River	Evergreen
Tonzi	Woody savanna/grass

First we examined the extent to which midday values (corresponding to satellite overpass times) of GPP and NPP are correlated with weekly-integrated values of the same variables. We used flux data for 2001-2004, to coincide with the dates of availability of MODIS data.

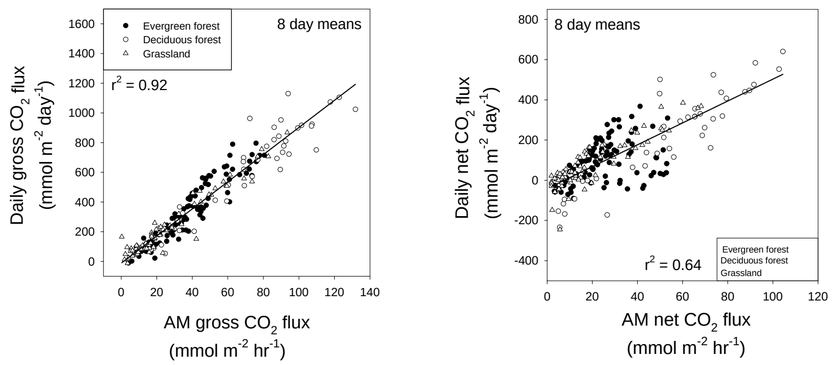
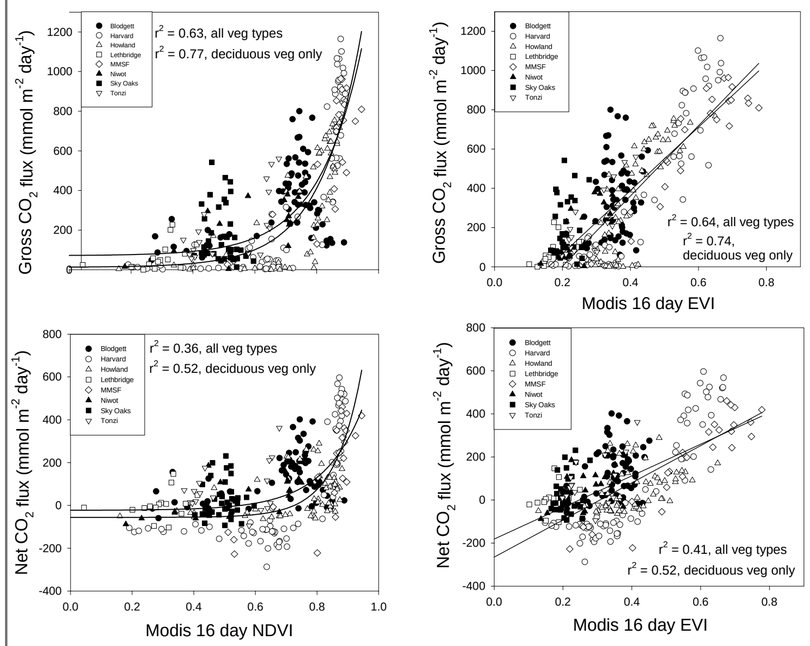


Figure: The ecosystem CO_2 fluxes during satellite overpass time were well correlated with the 8-day integrated flux values. The correlation was stronger for GPP than for NPP, indicating the difficulty of estimating respiration, which is composed of both autotrophic and heterotrophic contribution.

Next, we compared the relationships between the MODIS vegetation indices (NDVI and EVI) and fluxes (GPP and NPP).

Since the MODIS NDVI and EVI are available as 16-day composite products, we compared these indices with 16-day integrated values of GPP and NPP.



These results suggest that the 'EVI vs. fluxes' relationship can be used for direct estimation of 'per-pixel' carbon sequestration. We predict that this simple method of mapping spatially distributed carbon fluxes can be used for baseline determination in a wide range of project analyses related to carbon sequestration economics. Maps of EVI-derived GPP of three of our study sites are shown below.