2.10 Seasonal course of a normalized differential vegetation index 'NDVI' derived from tower data

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1. Introduction

Vegetation Indices (VIs) like the Normalized Differential Vegetation Index (NDVI) are widely used to monitor seasonal, interannual, and long-term variations of structural, phenological, and biophysical parameters of land surface vegetation cover. They are spectral transformations of at least two spectral bands, chosen specifically to enhance the contribution of vegetation properties to surface reflectances. Remote sensing products generally produce information on GPP (or net primary productivity, NPP), in terms of a light use efficiency (ε) and the amount of absorbed visible sunlight (Field et al., 1995; Ruimy et al., 1996; Running et al., 1999):

$$GPP = \varepsilon(T,\theta,D)\cdot fpar \cdot Q_p \qquad (1)$$

In practice, light use efficiency (ε) is adjusted for seasonal changes in soil moisture, temperature and vapor pressure deficit and the fraction of absorbed photosynthetically active radiation, fpar, is inferred from the NDVI (Xiao et al., 2004).

2. Results and discussion

With the FLUXNET network database spanning a wide range of plant functional types, disturbance features, and climates we have the ability to revise and improve upon Equation 1 as a tool for converting remote sensing information to terrestrial biosphere carbon flux information. In particular we can explore the modulating effects of direct and diffuse radiation, temperature acclimation, soil water deficits, frost/freezing, phenology and growth on light use efficiency (ε) using continuous and direct field measurements. And at field sites with up and downwelling quantum sensors, we can evaluate how well fpar is being assessed by the satellites.

We assess a broad-band version of the normalized difference vegetation index (NDVI) using reflectance measurements of visible (Qpar) and shortwave (Rg) solar radiation to represent contributions from reflected near infrared and visible radiation (Huemmrich et al., 1999), which in turn scales with fpar and leaf area index (Sellers, 1987) for 21 FLUXNET sites:

$$NDVI_{tower} = \frac{(R_g - Q_p)|_{nir} - Q_{par}|_{vis}}{(R_g - Q_p)|_{nir} + Q_p|_{vis}} \qquad (2)$$

While we measure R_g with a pyranometer and Q_p with a quantum sensor, work by Ross and Sulev (2000) indicates that we can convert the reflected quantum flux density to an energy flux density with a conservative conversion factor (4.6 μmol m^{-2} s^{-1} (W $m^{-2})^{-1}$). Using the combination of tower based and satellite-derived fpar and eddy flux data, outlined above, we can show the following results:

The seasonality of MODIS and Tower NDVI agrees very well for deciduous broadleaf forest sites as shown in Fig.1.

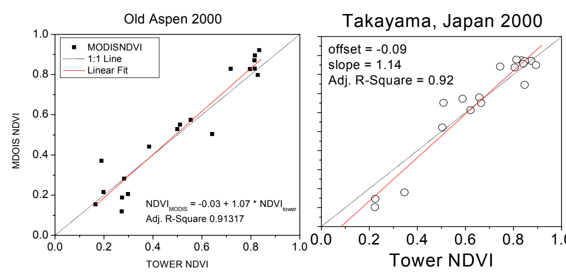

Figure 1: The relationship between MODIS NDVI and Tower NDVI for two deciduous forests

The broadband Tower NDVI saturates faster during the peal growing season for these sites leading to a steeper slope for peak Net ecosystem Productivity (NEP) and Gross Ecosystem Productivity (GEP) when plotted against MODIS and Tower NDVI as shown in Fig. 2.

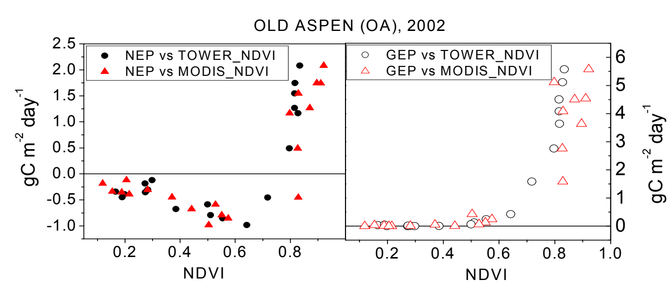

Figure 2: The relationship between both MODIS and Tower NDVI and GEP as well as NEP for a boreal deciduous forest.

For coniferous forests MODIS and Tower NDVI show a consistent offset but generally agree well in seasonality (see Fig. 3). A reduced range of NDVI for both Tower and MODIS products is evident for temperate coniferous forests whereas boreal coniferous forests show a more pronounced seasonal pattern.

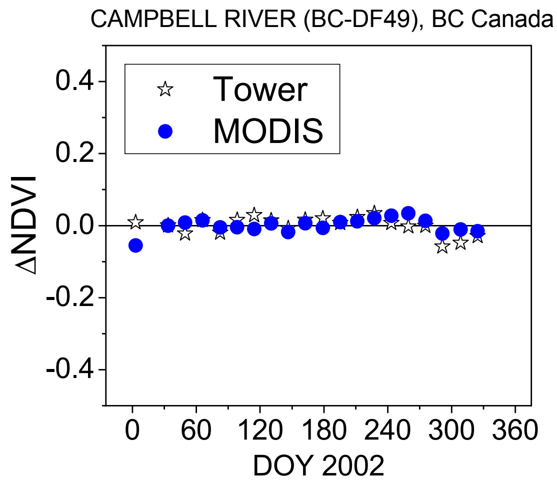

Figure 3: A comparison of the seasonal variation of MODIS and Tower NDVI for a temperate conifer forest on Vancouver Island, BC, Canada. The mean NDVI has been removed from both time series.

The tower broadband derived NDVI together with flux estimates enables us to verify whether the tower fluxes are representative to the smallest MODIS grid scale, i.e. is the seasonality of reflectance detected by MODIS representative for the flux tower site.

For an annual grassland in California that is surrounded by oak savanna the Tower and MODIS estimates of NDVI agree well during the winter and autumn, when the trees are leafless,. During the late spring and summer period, when the trees are green and the grass is dead, there is some disagreement between the two indices (see Fig. 4). Obviously, a better understanding of the sub-pixel heterogeneity of landscapes will be critical for utilizing Eq. 1 to compute local and regional scale carbon fluxes with MODIS. For another grassland site in the south-eastern US which is surrounded by patchy woodlands there is little correlation between the MODIS and Tower NDVI indicating a mismatch between tower footprint and regional land cover.

As more sites are adding sensors necessary to compute the broad-band version of NDVI and the FLUXNET Data Information System (DIS) is cataloguing the MODIS fpar, NDVI and the enhanced vegetation index (EVI) measurements around each tower site, we will develop transfer functions between the tower-based measurement of NDVI and satellite-based estimates of fpar, EVI and NDVI.

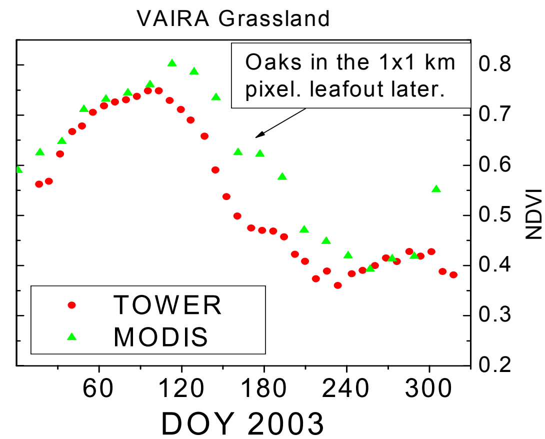

Figure 4: A comparison of the seasonal variation of NDVI measured with the broadband index (Equ. 2) and with the MODIS system. The site is an annual grassland, situated in a larger region of oak savanna. When the trees are deciduous, the two indices agree well

3. References

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.Acknowledgements

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