

Initial BigFoot Project Assessment of MODIS-derived Surfaces Related to the Global Carbon Cycle

W.B. Cohen¹, Stith T. Gower², David P. Turner³, Steven W. Running⁴

¹Research Forester, USDA Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331, warren.cohen@orst.edu; ²Professor, Department of Forestry, University of Wisconsin, Madison, WI 53706, stgower@facstaff.wisc.edu; ³Assistant Professor, Forest Science Department, Oregon State University, Corvallis, OR 97331, turnerd@fsl.orst.edu; ⁴Professor, School of Forestry, University of Montana, Missoula, MT 59812 (406)243-6311, swr@ntsg.umt.edu

Abstract – The global carbon cycle is one of the most important foci of an emerging global biosphere monitoring system. A key component of such a system is the MODIS sensor, onboard the Terra satellite platform. Biosphere monitoring requires an integrated program of satellite observations, Earth-system models, and *in situ* data. Related to the carbon cycle, MODIS science teams routinely develop a variety of global surfaces such as land cover, leaf area index, and net primary production using MODIS data and functional algorithms. The quality of these surfaces must be evaluated (or validated) to determine their effectiveness for global biosphere monitoring. This paper briefly describes the validation efforts of a project called BigFoot (<http://www.fsl.orst.edu/larse/bigfoot/>), an organized effort across nine biomes to assess the quality of the abovementioned surfaces.

I. INTRODUCTION

The BigFoot project includes nine distinct biomes: (1) Arctic tundra; (2) boreal evergreen needle-leaved forest; temperate (3) cropland, (4) grassland, (5) evergreen needle-leaved forest, and (6) deciduous broad-leaved forest; desert (7) grassland and (8) shrubland; and (9) tropical evergreen broad-leaved forest. Each biome is represented by a site that has an eddy-covariance flux tower that measures water vapor and CO₂ fluxes. Flux tower footprints are relatively small—approximately 1 km². BigFoot characterizes 25 km² around each tower, using field data, Landsat ETM+ image data, and ecosystem process models. Our field sampling design is a nested spatial series to facilitate geostatistical analyses. Field data are used both to develop site-specific algorithms for mapping/modeling the variables of interest and to characterize the errors in derived BigFoot surfaces. Direct comparisons of BigFoot- and MODIS-derived surfaces are made to help understand the sources of error in MODIS-derived surfaces and to facilitate improvements to MODIS algorithms (Cohen and Justice 1999). Early results from four BigFoot sites are presented.

II. METHODS

BigFoot maps of land cover and LAI are for 5 x 5 km areas at each site. The maps are derived using empirical

algorithms (Cohen et al. in review). Land cover is determined in the field and from airphotos and digital aerial images for a minimum of 100 points. Using a combination of regression analysis, unsupervised classification, and hand-editing, we create a series of land cover-related maps. These include percent tree or woody cover, and classes from the IGBP classification system used by MODIS science teams (<http://geography.bu.edu/landcover/>). The objective for BigFoot is to derive as accurate a set of land cover maps as possible that are relevant to site-specific processes within a given BigFoot site. As such, our land cover maps have modifiers to further subdivide land cover as needed; e.g., IGBP cropland into corn and soybeans. LAI maps are derived from regression analyses, using cover class-specific models where appropriate.

Comparisons with MODIS data include direct overlay and summary of BigFoot and MODIS maps for appropriate periods. For land cover we compare BigFoot Year-2000 maps with Version 3 land cover maps from MODIS for the same year. For LAI, a more ephemeral vegetation property for some biomes, there are no Version 3 products for 2000. Version 2 products for 2000 were based on improperly calibrated MODIS data that can only be used cautiously. Because two of the four sites are forested, and thus have relatively stable LAI, we used Version 3 2001 LAI products for the comparisons with BigFoot 2000 maps.

The MODIS LAI algorithm was run with the ETM+ images used to derive the BigFoot maps. This permitted isolating the effect of the LAI algorithm: BigFoot empirical versus MODIS radiative transfer. These comparisons involved differencing the two LAI maps, where appropriate, and characterizing the differences in terms of land cover class.

III. RESULTS

BigFoot maps of land cover and LAI can be viewed at <http://www.fsl.orst.edu/larse/bigfoot/data.html>. The maps show a fine-grained land cover pattern and coincident fine-grained LAI patterns associated with land cover variations.

At the boreal forest site (NOBS), nearly 80% of the land area is classified by MODIS as evergreen needle-leaf forest (ENF). BigFoot maps for this site classify the area predominantly as woody savanna (30%), savanna (20%), and open shrub (20%). The balance of the MODIS map is largely in the mixed forest class, whereas in the BigFoot map the balance is split among ENF, deciduous broad-leaf forest (DBF), and wetland. Averaged over 1 km x 1 km cells, the BigFoot maps predict a range of LAI values from 1.5 to 4.0, with a mean of about 2.75. The MODIS LAI map predicts LAI values from about 2.75 to 6.5, with a mean of about 3.75. Results from the MODIS algorithm used in conjunction with the ETM+ data, suggest that the algorithm overpredicts (in relation to BigFoot predictions) LAI by a value between around 1.0 and 2.0 for the wetland, open shrub, and closed shrub classes. For the woody savanna and ENF classes the algorithm underpredicts LAI by about 2.0 and 4.0, respectively. For DBF and savanna there is no bias relative to BigFoot.

For the Harvard Forest site (HARV), both BigFoot and MODIS classified the area as about 60% DBF. BigFoot classified most of the remaining area as mixed forest (20%) and ENF (15%), whereas MODIS classified the remaining area almost exclusively as mixed forest (35%). MODIS predicted LAI values for the site to range between 6 and 6.5. BigFoot LAI values averaged over 1 km cells range between 3.0 and 5.25. The MODIS algorithm used in conjunction with the ETM+ showed that the algorithm overpredicts on the three major classes present by an average of about 3.0.

At the agricultural site (AGRO), MODIS classified the area as exclusively cropland. BigFoot classified the area as 90 % cropland (split nearly equally between corn and soybeans). BigFoot predicted LAI values over 1 km cells at this site between 1.5 and 4.0 in July and between 2.0 and 6.0 in August. As the LAI values at this site are more ephemeral than at the forested sites, no LAI comparisons with MODIS for 2000 were made. The MODIS LAI algorithm failed to produce a prediction for 40% of the area. For the area where a prediction was made, LAI was overestimated by 3.0 in corn and by 5.0 in soybeans.

The grassland site (KONZ) was classified by MODIS as 75% grassland, with the remainder split between cropland and woody savanna. BigFoot classified the site as 65% grassland, 20% open shrub, 10% woody savanna, and 5% DBF. Over 1 km cells, BigFoot predicts LAI values between 1.75 and 3.25. Again, as the LAI values at this site are more ephemeral than at the forested sites, no LAI comparisons with MODIS for 2000 for this site. The MODIS LAI algorithm applied to the ETM+ data resulted in an overprediction of LAI by about 3.0 across most of the major classes at the site.

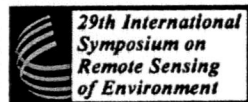
ACKNOWLEDGEMENTS

We thank Ranga Myneni and Nikolay Shabanov for supplying the radiative transfer model predictions using the ETM+ data. This research was funded by the Terrestrial Ecology Program at NASA.

REFERENCES

- Cohen, W.B. and C.O. Justice. 1999. Validating MODIS terrestrial ecology products: linking in-situ and satellite measurements, *Remote Sensing of Environment* 70:1-3.
- Cohen, W.B., T.K. Maierpserger, S.T. Gower, and D.P. Turner. Submitted November 2001. Empirical modeling of biophysical variable using Landsat ETM+ data, *Remote Sensing of Environment*.

BUENOS AIRES 2002
29th International
Symposium on Remote
Sensing of
Environment



"Information for
Sustainability and
Development"
April 8 - 12, 2002
Buenos Aires
ARGENTINA

