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CMS: LiDAR-derived Aboveground Biomass, Canopy Height and Cover for Maryland, 2011

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Documentation Revision Date: 2016-07-12

Data Set Version: V1

Summary

This data set provides 30-meter gridded estimates of aboveground biomass (AGB), canopy height, and canopy coverage for the state of Maryland in 2011. Leaf-off LiDAR data were combined with high-resolution leaf-on agricultural imagery to select 848 field sampling sites for biomass measurements. The field-based estimates were related to LiDAR height and volume metrics through random forests regression models across three physiographic regions of Maryland.

Funding for this work came from the NASA Carbon Monitoring system (CMS) project (NNX12AN07g - PI, Ralph Dubayah). The data for canopy cover, canopy height and biomass were developed through collaboration between the University of Maryland, the University of Vermont, and the USDA Forest Service.

There are 7 data files in GeoTIFF (.tif) format included in this data set.

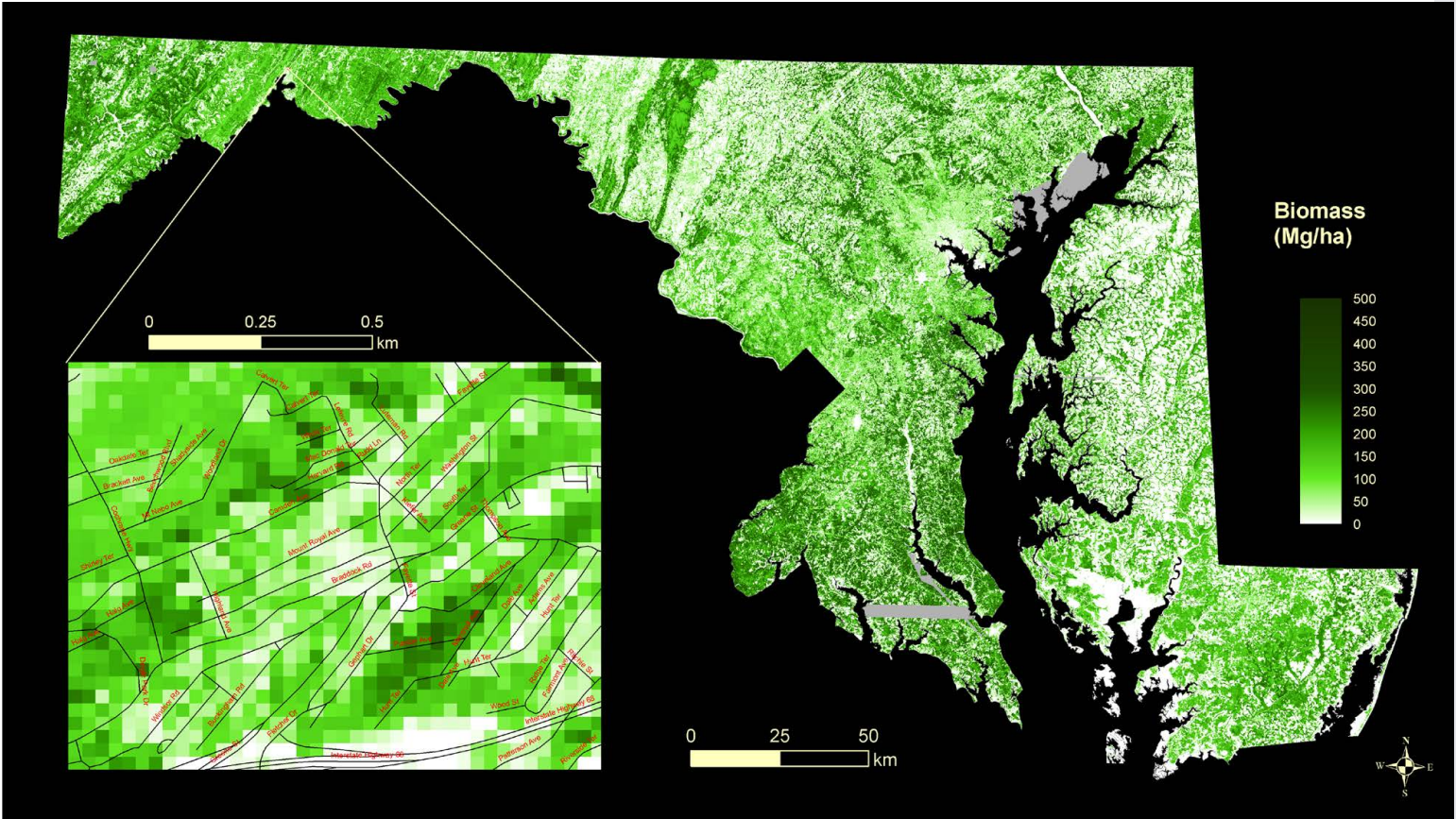


Figure 1. Aboveground biomass (Mg ha⁻¹) at 30-m resolution for the state of Maryland, 2011. Areas in grey (value = -1) indicate gaps in LiDAR coverage.

Citation

Dubayah, R.O., A. Swatantran, W. Huang, L. Duncanson, K. Johnson, H. Tang, J.O. Dunne, and G.C. Hurtt. 2016. CMS: LiDAR-derived Aboveground Biomass, Canopy Height and Cover for Maryland, 2011. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1320>

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1. Data Set Overview

Project: Carbon Monitoring System (CMS)

This data set provides 30-meter gridded estimates of aboveground biomass (AGB), canopy height, and canopy coverage for the state of Maryland in 2011. Leaf-off LiDAR data were combined with high-resolution leaf-on agricultural imagery in a model-based stratification that was used to select 848 sampling sites for AGB estimation. Field-based estimates were then related to LiDAR height and volume metrics through random forest regression models across three physiographic regions of Maryland. Spatial errors were estimated at the pixel level using standard prediction intervals to assess the accuracy of the modeling approach. Estimates of biomass were further validated against the permanent network of FIA plots and compared with existing coarse resolution national biomass maps.

Tree canopy height and forest cover were mapped at 1-meter resolution using the first and last returns within a high-resolution LiDAR data set. Heights for forested areas within each pixel were then aggregated to create a percentile height distribution within 30-meter pixels.

The NASA [Carbon Monitoring System](#) (CMS) is designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks through improved monitoring of carbon stocks and fluxes. The System will use the full range of NASA satellite observations and modeling/analysis capabilities to establish the accuracy, quantitative uncertainties, and utility of products for supporting national and international policy, regulatory, and management activities. CMS will maintain a global emphasis while providing finer scale regional information, utilizing space-based and surface-based data and will rapidly initiate generation and distribution of products both for user evaluation and to inform near-term policy development and planning.

Related Data:

Cook, B., A. Swatantran, L. Duncanson, A. Armstrong, N. Pinto, R. Nelson. 2014. CMS: LiDAR-derived Estimates of Aboveground Biomass at Four Forested Sites, USA. Data set. Available on-line [<http://daac.ornl.gov>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1257>

Hagen, S., N. Harris, S.S. Saatchi, T. Pearson, C.W. Woodall, S. Ganguly, G.M. Domke, B.H. Braswell, B.F. Walters, J.C. Jenkins, S. Brown, W.A. Salas, A. Fore, Y. Yu, R.R. Nemani, C. Ipsan, and K.R. Brown. 2016. CMS: Forest Carbon Stocks, Emissions, and Net Flux for the Conterminous US: 2005-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1313>

Kellndorfer, J., Walker, W., Kirsch, K., Fiske, G., Bishop, J., LaPoint, L., Hoppus, M., and Westfall, J. 2013. NACP Aboveground Biomass and Carbon Baseline Data, V. 2 (NBCD 2000), U.S.A., 2000. Data set. Available on-line [<http://daac.ornl.gov>] from ORNL DAAC, Oak Ridge, Tennessee, U.S.A. <http://dx.doi.org/10.3334/ORNLDAAC/1161>

2. Data Characteristics

Spatial Coverage: Maryland, US

Spatial Resolution: 30 meter

Temporal Resolution: One-time estimate for the year 2011

Temporal Coverage: 20110101 to 20111231

Spatial Extent:

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Maryland	-79.71	-74.82	39.95	37.69

Data File Information

There are 7 data files in GeoTIFF (.tif) format included in this data set. The 30-meter resolution maps depict aboveground biomass, canopy height, and percent tree cover for the state of Maryland. Also included are spatial representations of estimated uncertainty and data coverage. All biomass data are given units of in megagrams (Mg) per hectare and the canopy height data is in meters. Descriptions of the files are included in Table 2.

Table 2. File descriptions

Filename	Description	Values
Maryland_Biomass_QRF_High_30m.tif	95 th percentile of mean AGB (Mg/ha)	>0 = Estimated AGB -1 = No LiDAR data -9999 = fill value
Maryland_Biomass_QRF_Low_30m.tif	5 th percentile of mean AGB (Mg/ha)	>0 = Estimated AGB -1 = No LiDAR data -9999 = fill value
Maryland_Biomass_RF_30m.tif	Aboveground biomass (Mg/ha)	>0 = Estimated AGB -1 = No LiDAR data -9999 = fill value
Maryland_CanopyHeight_30m.tif	Canopy height (m)	>0 = Canopy height -1 = No LiDAR data -9999 = fill value
Maryland_LidarYear_30m.tif	LiDAR flight year	20## = year 0 = out of state fill value
Maryland_MissingLidarMask_30m.tif	LiDAR coverage gap mask	0 = LiDAR coverage 1 = no LiDAR coverage 255 = out of state fill value
Maryland_PercentTreeCover_30m.tif	Tree canopy cover	Expressed as a fraction from 0 to 1

Spatial Data Properties

Spatial Representation Type: Raster
Pixel Depth: 32 bit float & 8 bit integer
Pixel Type: float/integer
Compression Type: LZW
Number of Bands: 1
Raster Format: TIFF
No Data Value: -9999
Scale Factor: 1

Number Columns: 12774
Column Resolution: 30 meters
Number Rows: 7002
Row Resolution: 30 meters

Extent in the item's coordinate system
North: 4406400
South: 4196340
West: 112500
East: 495720

3. Application and Derivation

The approach used to generate this data set can be replicated to provide accurate, unbiased AGB estimates at fine spatial resolution in other areas with LiDAR data coverage. High-resolution maps of AGB provide a valuable bottom-up reference to improve the analysis and interpretation of large-scale maps produced

through NASA's CMS project.

Huang et al. (2015) demonstrated this type of application by comparing the modeled biomass data for the state of Maryland with four national biomass products to evaluate their accuracy: (1) the NBCD2000 (<http://dx.doi.org/10.3334/ORNLDAAC/1161>), and maps developed by (2) Blackard et al. (2008), (3) Wilson et al. (2013), and (4) Hagen et al. (<http://dx.doi.org/10.3334/ORNLDAAC/1313>). Each biomass map was aggregated to 500-m, 1-km, and 4-km resolutions for comparison at the pixel, county, and state levels for forested and non-forested areas. Spatial patterns of biomass were broadly consistent in all maps, but the accuracy assessment revealed large differences at fine scales. Discrepancies reduce with aggregation and the agreement of the modeled biomass product improves at the county level. Further details of their analysis can be found in Huang et al. (2015).

4. Quality Assessment

Uncertainty in the AGB estimates derives from multiple factors, including, but not limited to: field sampling errors and uneven spatial distribution, uncertainty in remote-sensing data products, choice of grid cell size, and model error. Random forest is a well-known machine learning procedure widely employed in biomass estimation. It suffers from a common problem of underestimation of high biomass values. To overcome this limitation and to provide robust error bounds, a quantile random forest approach was utilized that allows for error bounds to be predicted. This approach was evaluated in a pilot study for two Maryland counties. The resulting data set is available at the ORNL DAAC (<http://dx.doi.org/10.3334/ORNLDAAC/1257>).

Spatially-gridded estimates of the upper and lower bounds of the 95% confidence interval of the mean are provided at 30-m spatial resolution as part of this data set.

5. Data Acquisition, Materials, and Methods

The biomass map was generated using the LiDAR data and field estimates from 848 variable and fixed radius plots selected through stratified sampling of the National Land Cover Database (NLCD) for 2011 (Homer et al. 2015). Tree measurements of diameter at breast height were recorded in each plot. Allometric estimates of aboveground biomass (Mg ha⁻¹) were calculated for each tree using equations from Jenkins et al. (2003) and appropriate blow up factors were applied to estimate biomass density for the variable radius plots. Model validation was performed through local comparisons with FIA data. Field sample data will be made available in forthcoming data sets.

Field-based estimates of biomass were then related to the LiDAR metrics using Random Forests regression models. Three separate models were applied to predict biomass for three distinct physiographic regions of Maryland based on species-composition and environmental gradients: (1) the Eastern Coastal Plain, (2) the combined Western Coastal Plain and Piedmont, and (3) the combined blue Ridge, Valley, and Central Appalachians. Predictions over individual counties within each physiographic region were merged to produce the statewide biomass map at 30-meter resolution (Huang et al., 2015). A generalized workflow for these methods and how they relate to national mapping efforts is depicted below in Figure 2.

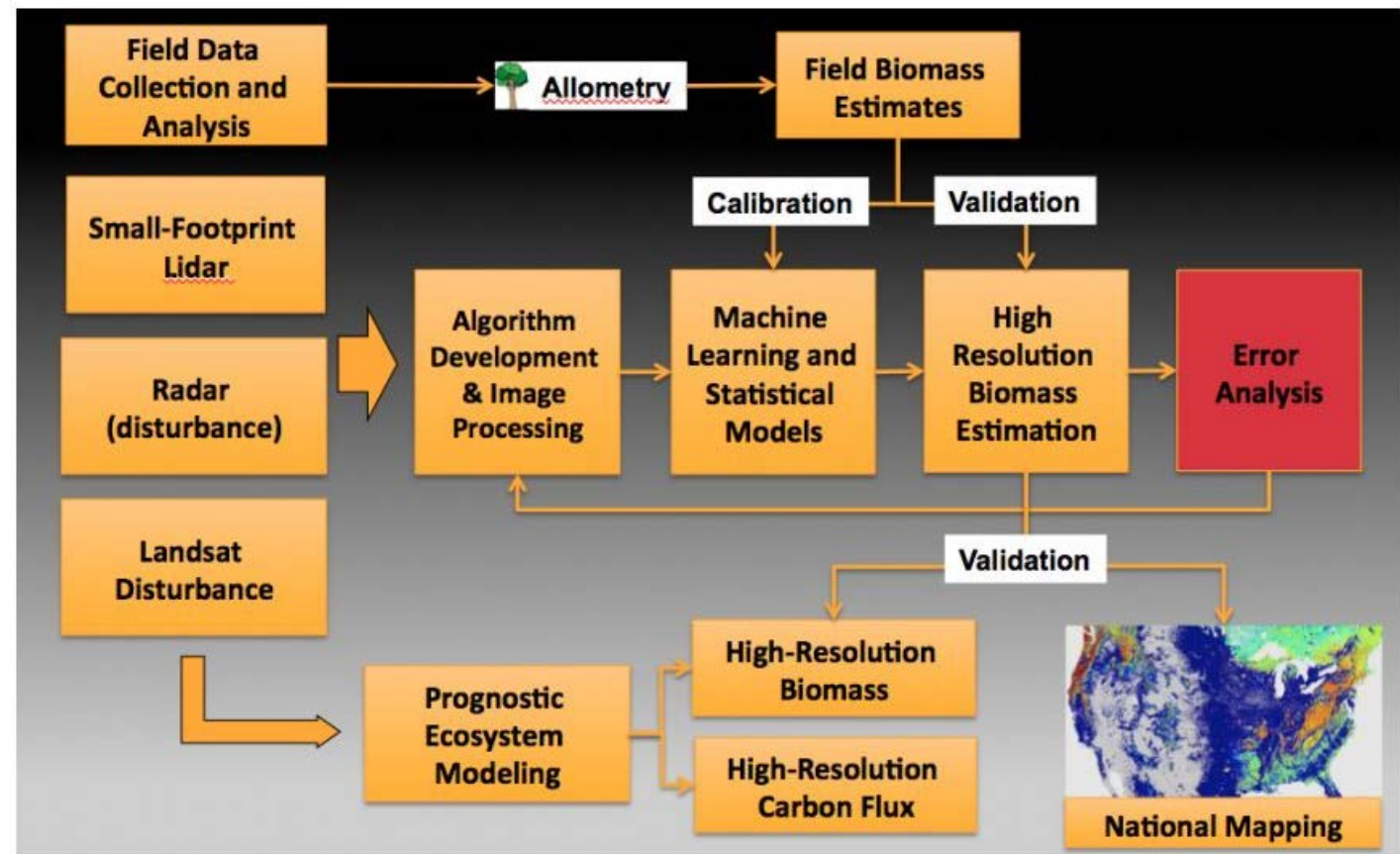


Figure 2. Overall methodology for integrating local-scale field and remote sensing measurements and their relationship to national mapping efforts, from Huang et al. (2015).

Tree canopy height and forest cover were mapped at 1-meter resolution using the first and last returns within the LiDAR data. Heights for forested areas within each pixel were then aggregated to create a percentile height distribution within 30-meter pixels.

6. Data Access

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[CMS: LiDAR-derived Aboveground Biomass, Canopy Height and Cover for Maryland, 2011](#)

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

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