Error estimation and validation of global tree-cover continuous fields using lidar remote sensing

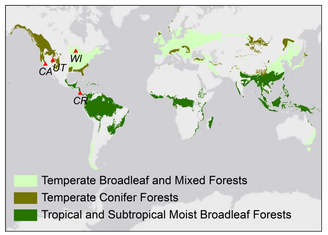
Anupam Anand*, Joseph O. Sexton, Xiao-Peng Song, Min Feng, Praveen Noojipady, Chengquan Huang, Do-Hyung Kim, Saurabh Channan, John R. Townshend
Global Land Cover Facility, Department of Geographical Sciences, University of Maryland. *anupam@umd.edu

INTRODUCTION

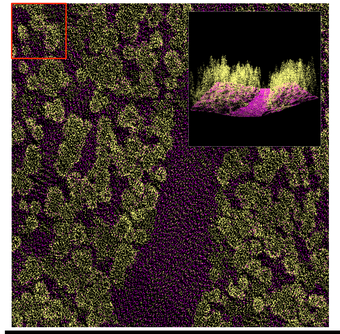
Validating tree cover estimates is limited by scale and cost. With increasing coverage worldwide, light detection and ranging (lidar) sensors now offer an additional and potentially superior means of reference data collection. We created a global, Landsat-based tree cover dataset for circa 2000 and 2005 and assessed its accuracy relative to lidar measurements and the MODIS Vegetation Continuous Fields tree cover layer in a sample of biomes.

METHODS

- Global, 30-m estimates of tree cover in 2000 and 2005 were generated by a scale-free model of cover as a function of surface reflectance. The model was fit locally to cover estimates from the 250-m Moderate-resolution Imaging Spectroradiometer (MODIS) Vegetation Continuous Fields (VCF) tree cover layer and ancillary information from the MODIS Cropland Layer and Training Data Automation-Support Vector Machines (TDA-SVM).
- Lidar measurements of tree cover were calculated by dividing the number of returns > 5 m in height by the total number of returns within a 10-m radius.

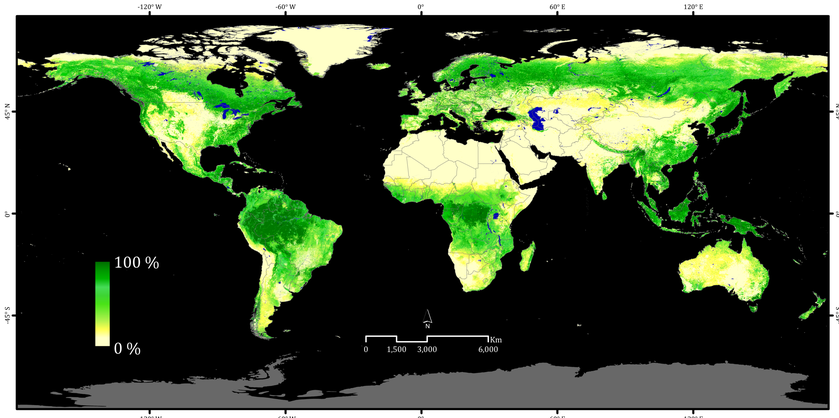


Geographic distribution of test sites relative to global biomes: La Selva Biological Station, Costa Rica (CR); Wasatch Front, Central Utah (UT); Sierra National Forest, California, (CA); and Chequamegon-Nicolet National Forest, Wisconsin (WI).



Lidar point density within a single 250x250-m (MODIS) pixel. Area of one 30-m Landsat pixel is shown in the upper-left corner. Lidar returns are classified by height into tree (yellow) and non-tree (purple). Data shown are from the CA site.

All sites had point densities >1/m^2. Inset shows the same data in oblique perspective.



The 2000 and 2005 Landsat-based tree cover dataset is available for free download at the Global Land Cover Facility website:(www. landcover.org).

All sites

Regression	Intercept (S.E.)	Slope (S.E.)	R^2	$RMSE_s$	$RMSE_u$
MODIS ~ lidar	12.429 (0.549)	0.714 (0.008)	0.705	10.097	13.462
Landsat ~ MODIS	4.530 (0.323)	0.825 (0.005)	0.882	7.063	7.473
Landsat ~ lidar	10.016 (0.384)	0.668 (0.006)	0.811	14.637	9.406

Costa Rica (n=2044)

Regression	Intercept (S.E.)	Slope (S.E.)	R^2	$RMSE_s$	$RMSE_u$
MODIS ~ lidar	29.621 (0.756)	0.561 (0.010)	0.628	11.242	10.573
Landsat ~ MODIS	12.477 (0.572)	0.710 (0.008)	0.804	9.765	6.066
Landsat ~ lidar	24.593 (0.380)	0.517 (0.004)	0.850	16.640	5.312

California (n=289)

Regression	Intercept (S.E.)	Slope (S.E.)	R^2	$RMSE_s$	$RMSE_u$
MODIS ~ lidar	23.963 (1.835)	0.517 (0.042)	0.348	6.610	8.226
Landsat ~ MODIS	16.031 (1.548)	0.603 (0.033)	0.539	4.583	5.687
Landsat ~ lidar	22.248 (1.328)	0.506 (0.030)	0.494	5.893	5.955

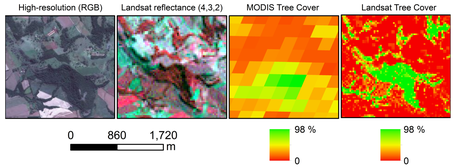
Utah (n=425)

Regression	Intercept (S.E.)	Slope (S.E.)	R^2	$RMSE_s$	$RMSE_u$
MODIS ~ lidar	6.069 (0.453)	0.365 (0.016)	0.552	13.556	5.500
Landsat ~ MODIS	-1.066 (0.372)	0.807 (0.022)	0.755	4.160	3.784
Landsat ~ lidar	3.316 (0.453)	0.318 (0.016)	0.483	16.766	5.492

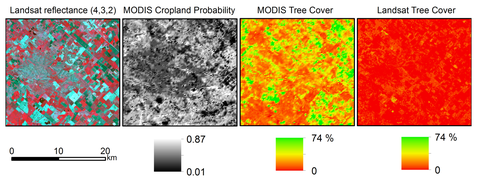
Wisconsin (n=655)

Regression	Intercept (S.E.)	Slope (S.E.)	R^2	$RMSE_s$	$RMSE_u$
MODIS ~ lidar	22.759 (0.888)	0.390 (0.013)	0.561	21.456	8.708
Landsat ~ MODIS	3.128 (1.384)*	0.941 (0.028)	0.619	0.856	9.699
Landsat ~ lidar	17.119 (0.809)	0.508 (0.012)	0.728	18.185	7.849

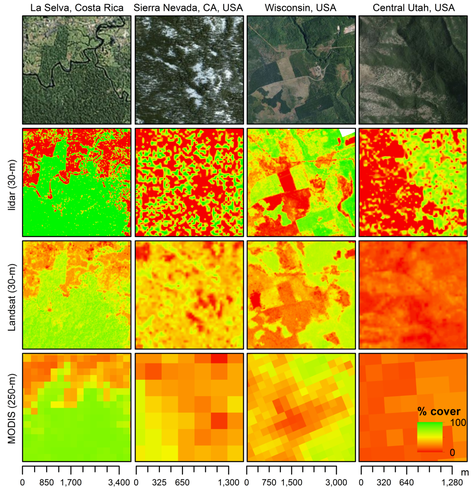
- Overall accuracy of GLS estimates is comparable to that of the MODIS VCF (RMSE = 17%).
- GLS estimates exhibit improved accuracy in difficult agricultural regions, with an RMSE of 20% in GLS vs. 23% RMSE in MODIS VCF.
- GLS has improved potential for calibration to lidar, with post-calibration RMSE = 9% vs. 14% in the MODIS VCF.



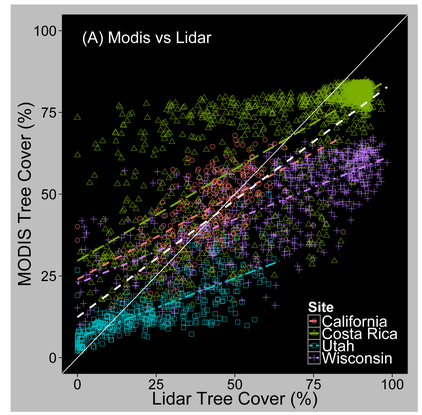
Resolution differences between MODIS- and Landsat-based tree cover estimates in a highly fragmented landscape. Site shown is in Paraná, Brazil (p224, r078).



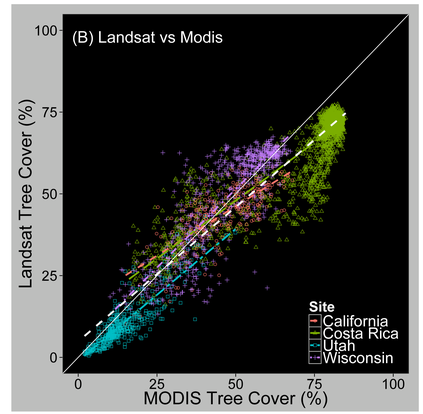
Accuracy of MODIS and Landsat-based tree cover estimates in an agricultural region. Site shown is in the Buenos Aires Province, Argentina (p225, r086).

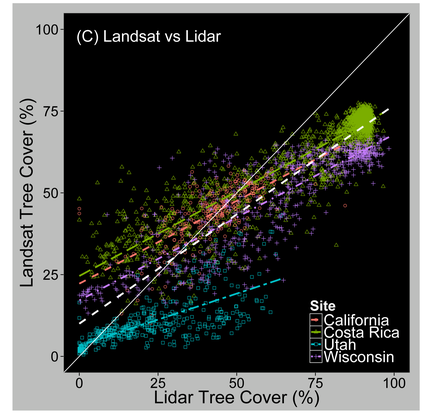


Resolution of tree cover by lidar, Landsat, and MODIS data. Both Landsat and MODIS estimates replicated lidar estimates with reasonable fidelity in large and discrete patches of forest cover. Landsat provides superior resolution of small surface features such as forest clearings However, complex height and cover gradients (e.g., UT) pose a continuing challenge for both datasets.



Lidar measurements vs. Landsat- and MODIS-based estimates. MODIS-based estimates vs. lidar measurements (A), Landsat- vs. MODIS-based estimates (B) and Landsat-based estimates vs. lidar measurements (C) Points and (dashed) regression lines are identified with sites by color, the overall (across-site) regression is in dashed white, and the 1:1 line is solid white.





REFERENCE

Sexton, J.O., X.-P. Song, M. Feng, P. Noojipady, A. Anand, C. Huang, D.-H. Kim, K.M. Collins, S. Channan, C. DiMiceli, J.R. Townshend. *in press*. Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS continuous fields and lidar-based estimates of error. *International Journal of Digital Earth*

The Global Land Cover Facility (GLCF) is sponsored by NASA programs, including EOS, MEaSUREs, LCLUC and the University of Maryland. The GLCF is a founding member of the Federation of Earth Science Information Partners (ESIPs) and is a member of the International Union for the Conservation of Nature (IUCN).