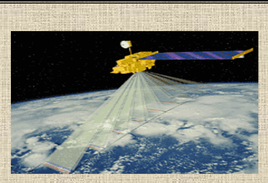

Changes in Aboveground Biomass in the Southwestern United States 2000-2009 from MISR

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Data from the NASA Multiangle Imaging Spectro-Radiometer (MISR) were used to drive a boosted regression tree model to estimate aboveground biomass (AGB) in the southwestern US for 2000 - 2009. Predictors included May 15 - June 15 MISR nadir camera bidirectional reflectance factors, MISR LiSparse-RossThin (non-reciprocal) bidirectional reflectance distribution function (BRDF) isotropic, volume scattering, and geometric scattering model kernel weights, RMSE and map coordinates, derived from MISR Level 1B2 Terrain radiance data. The NACP/National Biomass and Carbon Dataset (NBCD, Kellndorfer et al. 2013) was used to train a boosted regression tree model. The 240 m AGB data were resampled to the same 250 m Albers Conical Equal Area grid used for the MISR data. The calibration data consisted of training and validation data sets generated in two stages, including one set of 13,693 completely random points and a second set of 10,240 random points located in forest only. The combined set was filtered for cloud/cloud shadow/non-vegetated cases (LiSparse-RossThin model-fitting RMSE>0.01, NBCD AGB=0, and missing data) and divided randomly into training and validation data sets for model testing and (N= 2516 and 2459, respectively). The final model used a tree complexity of 10, a learning rate of 0.005, and 1200 trees. The model was tested using the validation data set yielding an R^2 of 0.73 (Figure 1). BRT models were constructed using four different combinations of predictors: the MISR An nadir camera BRFs and BRDF model kernel weights from inversion against MISR red band multiangle BRFs were always used; and model-fitting RMSE, Y, and X coordinates were added one-by-one. The results were assessed against independent random samples, with N=1013 for all sites and 3390 for forest sites only. The results using all predictors showed the best agreement, with R^2 of RMSE of 0.76 and 18.0 Mg ha^{-1} (all sites) to 0.71 and 17.7 Mg ha^{-1} (forest). The model was then applied with 2009 MISR data from the same period to obtain the estimated change in AGB over the period.

TABLE 1. MISR/BRT ABOVEGROUND BIOMASS ESTIMATES W.R.T. NBCD 2000 (V2)

	R^2	RMSE	Predictor Variables
Bio7	0.73	35.2	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol
Bio8	0.74	34.6	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE
Bio9	0.75	34.0	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE, Y
Bio10	0.80	30.6	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE, Y, X

Note: [1] MISR nadir-viewing camera [2] LiSparse-RossThin non-reciprocal model. N = 4975.

The model was used to construct aboveground biomass maps using four different combinations of predictors: MISR An (nadir) and red band multiangle BRFs were always used; and model-fitting RMSE, Y, and X coordinates were added one-by-one A mask was constructed to include valid Since no independent validation data are available for the entire region, the results were assessed against the NBCD 2000 estimates, in the first instance for the locations of the combined training and validation data sets (N=4975) – showing very good agreement, with RMSE down to 31 Mg ha^{-1} (Table 1) – and then for independent random points (Table 2).

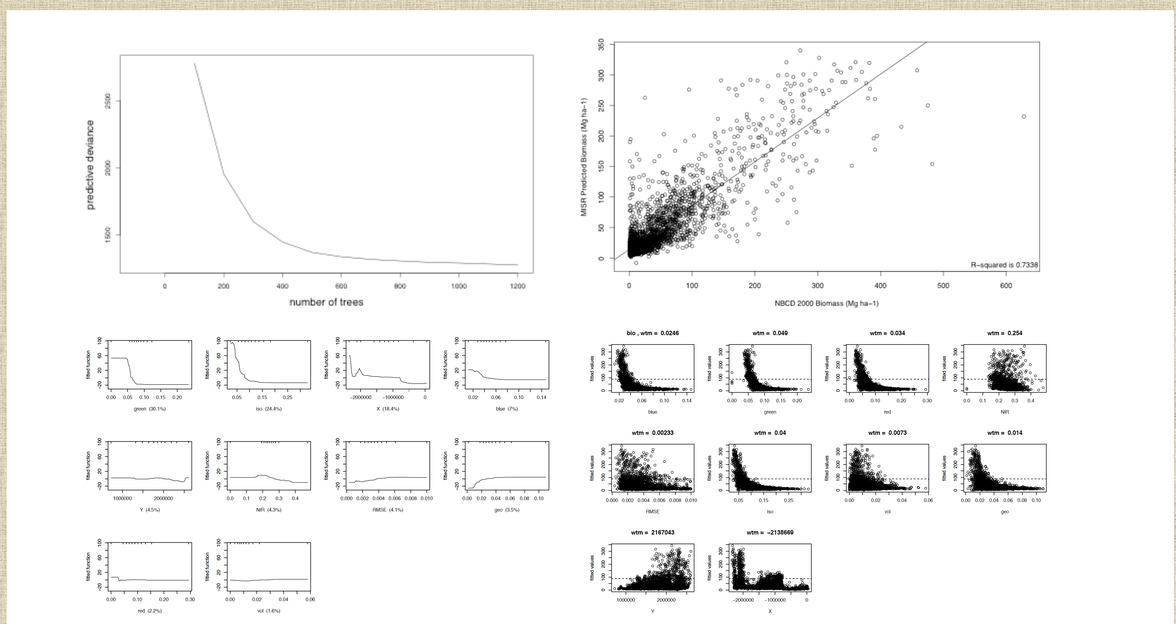

Figure 1. (a) BRT model estimate of number of trees vs predicted deviance (b) MISR 2000/BRT-predicted vs NBCD 2000 aboveground biomass, validation data set only, N = 2459 (c) Fitted functions showing contributions of predictor variables (d) Fitted values vs predictors.

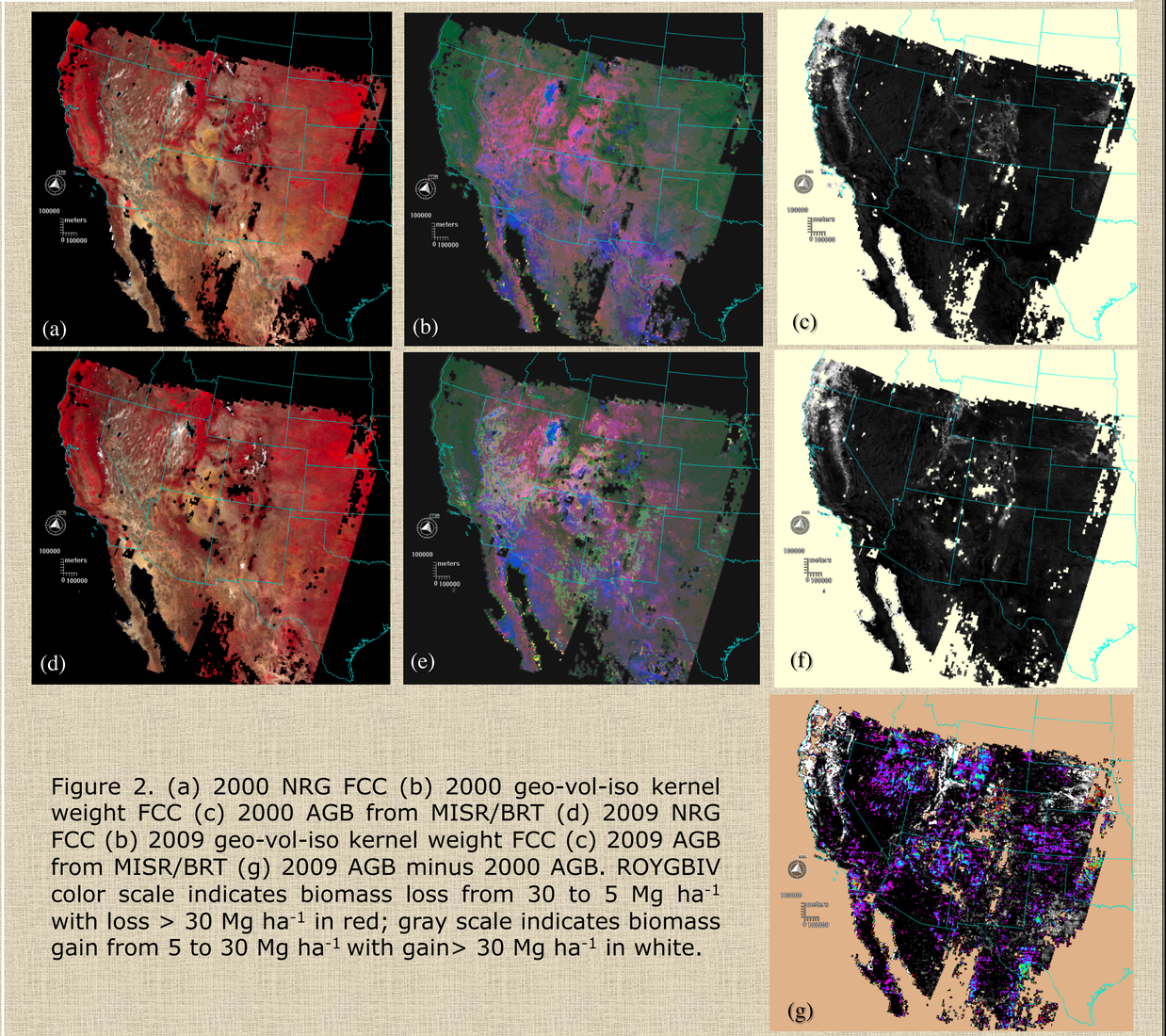

Figure 2. (a) 2000 NRG FCC (b) 2000 geo-vol-iso kernel weight FCC (c) 2000 AGB from MISR/BRT (d) 2009 NRG FCC (b) 2009 geo-vol-iso kernel weight FCC (c) 2009 AGB from MISR/BRT (g) 2009 AGB minus 2000 AGB. ROYGBIV color scale indicates biomass loss from 30 to 5 Mg ha^{-1} with loss > 30 Mg ha^{-1} in red; gray scale indicates biomass gain from 5 to 30 Mg ha^{-1} with gain> 30 Mg ha^{-1} in white.

TABLE 2. SUMMARY OF MISR/BRT AND GO MODEL BIOMASS PREDICTIONS VS NBCD 2000 (MGHA^{-1})

	R^2	RMSE	Predictor Variables
All-Bio7	0.69	36.7	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol
All-Bio8	0.69	20.5	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE
All-Bio9	0.69	19.0	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE, Y
All-Bio10	0.76	18.0	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE, Y, X
For-Bio7	0.63	38.7	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol
For-Bio8	0.64	21.1	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE
For-Bio9	0.64	19.2	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE, Y
For-Bio10	0.71	17.7	An[1]: Blue, Green, Red, NIR LiSpRThin[2]: iso, geo, vol, RMSE, Y, X

Note: [1] MISR nadir-viewing camera [2] LiSparse-RossThin non-reciprocal model. N = 1013 for all sites (All-) and 3390 for forest sites only (FOR-), after filtering for missing data and poorly-constrained BRDF model inversions.

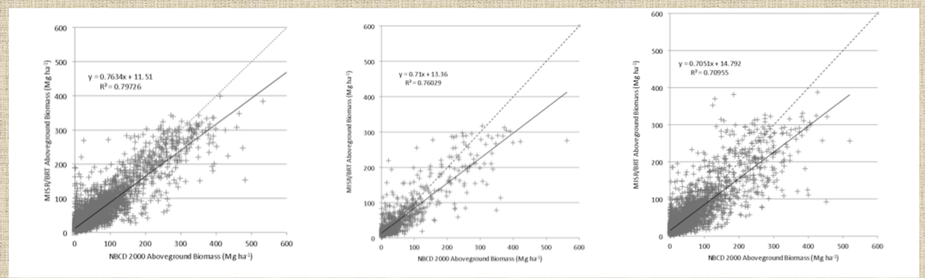

Figure 3. MISR/BRT vs NBCD 2000 aboveground biomass estimates (a) 4975 points used in training and validation (50/50 random split) (b) 1013 points filtered from 10,000 random points (c) 3390 filtered from 10,000 random points in forest only. Filtering was for missing data, model-fitting RMSE > 0.01 (cloud/shadow/non-vegetated) and NBCD 2000 values of zero.

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