Context: This research is aimed at mapping aboveground biomass (AGB, Mg ha⁻¹⁻¹) in dense Oregon forests using data from the NASA Multiangle Imaging Spectro-Radiometer (MISR). Efforts to exploit geometric-optical (GO) model inversion to map cover, height, and aboveground standing biomass were found to be problematic in these high cover environments (Fig. 1), so a boosted regression tree (BRT) approach was explored as a means to leverage the information in MISR Li-Ross Bidirectional Reflectance Distribution Function (BRDF) model kernel weights and associated parameters. 

MISR Data: MISR Level 1B2 Terrain radiance data from the Terra satellite overpass on 08/16/11 (Orbit 062028, Path 45, Blocks 55-56, centered on 44°32'N, 122°00'W) were converted to bidirectional reflectance factors (BRF) using MISR Toolkit routines and the MISR 1 km LAND product BRFs, and resampled onto a 250 m equal area grid. The data include nadir camera blue (B), green (G), and near-infrared (NIR) BRFs and red band BRFs in all nine MISR cameras. Surface BRFs were initially missing in very dark, high forest cover areas, with the MISR aerosol product showing an aerosol optical depth upper bound of zero for all mixtures, i.e., the aerosol retrieval fails. To mitigate this, the LAND albedo threshold was reduced to zero and the topographic complexity threshold was disabled, extending coverage (Fig 5).

BRDF and GO Model Inversions: Red band BRFs in all available cameras were used with AMBRALS to invert the RossThick-LiSparse-Reciprocal (RTLS-R) BRDF model to retrieve iso(tropic), vol(ume scattering), and geo(metric scattering) kernel weights, as well as model-fitting too mean square error (RMSE), weights of determination, white and black sky albedos, and BRDF-adjusted BRF at a solar zenith angle of 45 degrees (NBAR45). The red band BRFs were also used to invert a geometric-optical (GO) model using numerical minimization to retrieve estimates of fractional crown cover and mean canopy height.

Other Data: A 1-arcsecond (30 m) digital elevation model (DEM) from the National Elevation Dataset (NED) was used to calculate a topographic roughness map at 250 m in the following way: a 30 m slope map was calculated from the NED DEM; this was resampled to 50 m using bilinear interpolation; Focal Analysis with a 5x5 kernel and a St.Dev. function was used to produce roughness estimates that were subsequently degraded to obtain the 250 m roughness map (Grohmann et al. 2010). The National Biomass and Carbon Dataset (NBCD, Kellndorfer et al. 2013) was used to train the boosted regression tree model and in assessing the results of predictions. The 240 m Zone 6 data were resampled to the same 250 m Albers Conical Equal Area grid used for the MISR data.

Boosted Regression Tree Model: The MISR nadir B, G and NIR BRFs, BRDF model kernel weights, model-fitting error, albedos, NBAR45, and NBCD biomass data to train a Boosted Regression Tree (BRT) model. Boosted regression trees handle different types of predictor variables and accommodate missing data; these models have no need for prior data transformation or elimination of outliers, they can fit complex nonlinear relationships, and they automatically handle interaction effects between predictors (Elith et al. 2008). Training initially used two randomly-located sets of 1024 points each, removing data where BRDF model RMSE > 0.01. However, clear-cutting and regeneration are common, creating a problem when using the NBCD 2000 AGB data with 2011 MISR data (Fig. 1). continued...

Results: Using the improved training data set ("set 1") to fit a BRT model with a learning rate of 0.005, a tree complexity of 10, and 1200 trees, the optimum number of trees was ~600 yielding a prediction R² of 0.78 for the validation data set ("set 2"; Fig. 2). The two BRT models were used to predict AGB for a 1,251,600 ha region (Fig. 3 (a) and (e)) and the corresponding NBCD and MISR/BRT AGB values were extracted for the (random) set 1 and 2 locations. These show very good results compared with predictions via regression based on Simple GO Model (SGM) forest cover and height retrievals (Table 1, Fig. 4).

Conclusions: The BRT approach provides a means of mapping AGB using MISR BRFs and derived BRF model kernel weights with reasonable accuracy and better than that obtainable using a GO model in dense forests. The results presented here are based almost entirely on the NBCD 2000 data set with 2011 MISR data, so further work is required using temporally consistent data; and to validate results with independent data.

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