Producing a canopy height map over a large region using heterogeneous lidar datasets

Ranjith Gopalakrishnan (ranjith7@vt.edu), Dr. Valerie Thomas , Dr. John Coulston and Dr. Randolph Wynne

VirginiaTech

Motivation: Why care about a tree height map?

• Estimation of biomass, for carbon accounting, fuel load (eg: annual federal spending on wildfires increased from $1.4 billion (1990s) to $3.5 billion (2000s), adjusted for inflation.

•Currently, there is no good strategy to get forest parameter estimates over large areas using a combination of airborne LIDAR and (ground based) national forest inventory data. This work is a beginning in that direction.

Methods

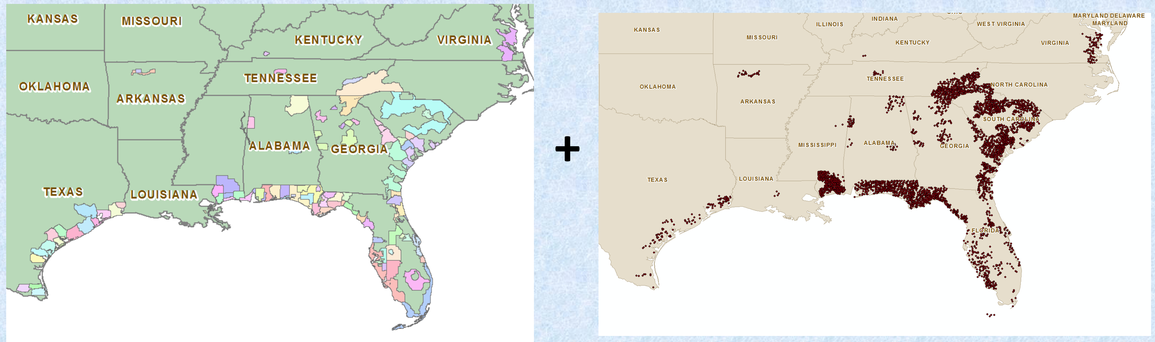

Fig 1: Left; LIDAR coverage, different projects are shown as different colors. Right; FIA plot coverage.

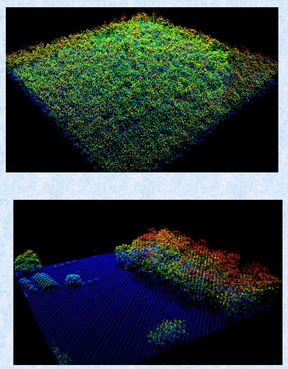

Fig 2: Homogeneous (top) and non-homogeneous lidar plots

- First, we acquired LIDAR data from USGS, NOAA and NRCS (AL) for a large area (fig 1), with LIDAR acquisition dates ranging from 2005 to 2011. Over 90 separate LIDAR projects are involved.
- Then, we intersected this data with FIA plot location data. This gave us 2084 plots (120 x 120 m) where we had both LIDAR and FIA field data (see fig 2 for two such typical plots).
- Then, simple linear regression models between the LIDAR parameters and FIA field measurements of tree heights, were made. The factors affecting the residual of the fit were then examined (next section).
- Understory: We compute ULCD, a lidar understory metric (Wing et al 2012) Then, we compared it to FIA's estimate of carbon in the aboveground understory (only P3 plots)

Results

Scatter: factors investigated

• Point density (num. lidar pulses/m^2)

•Plot homogeneity (surrogate for co-registration errors). Quantified by 1/CV (coeff. of var. of lidar pulse heights)

• % trees that are softwoods in the FIA plots (vs hardwoods)

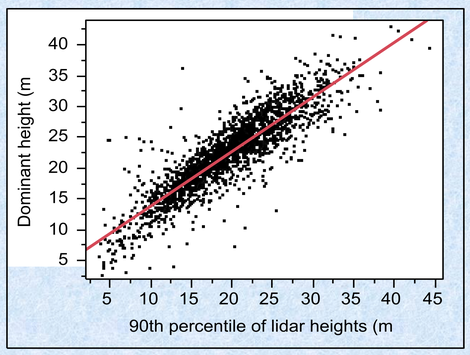

Fig 3: Simple linear regression fit of a lidar-based height metric, and the FIA-measured height, for n = 2084 plots. R_{adj}^2 = 0.78, RMSE = 2.94 m.

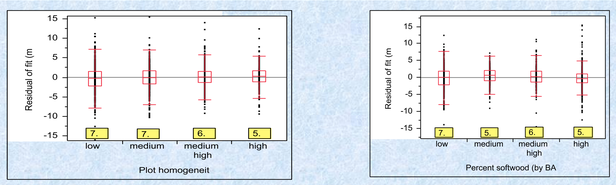

Fig 4: The effect of various factors, explored by boxplots. The values at the bottom (yellow box) are the quantile ranges, between the 10th and the 90th quantiles.

Results (contd.)

PD more than...	Homogeneity more than... 2.0 (least homog.)	2.50	3.33	5.00	6.67	10.0 (most homog.)
0.20	2.94	2.84	2.63	2.56	2.16	**1.46**
1.00	2.87	2.75	2.56	2.36	2.11	1.47
2.00	2.81	2.66	2.41	2.21	2.21	NA
4.00	2.56	2.52	2.44	2.06	NA	NA
6.00	2.93	2.99	2.86	2.23	NA	NA

Table 1: The effect on RMSE (in meters) of thresholding homogeneity and PD (point density).

Understory: initial results

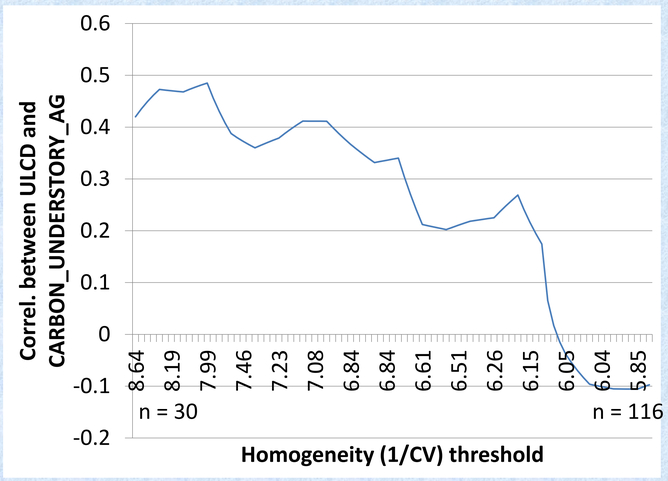

Figure 6: Correlation between lidar and FIA understory metrics. The correlation is fair to start off with and degrades for homogeneity > 6.0

Managed Loblolly Pine

Managed loblolly pine plots are FIA forest plots where: 1) There is only one land use; 2) Forest artificially regenerated; 4) Loblolly species basal area > 70%. Also, to avoid possible co-registration issues we keep homogeneity > 2.0

Loblolly basal area (greater than)	Num. FIA plots	RMSE (m.)
99%	59	2.30
95%	99	2.04
90%	128	1.95
85%	139	1.92
80%	143	1.91
70%	**161 (see map below)**	1.88

Table 2: The effect on RMSE (in meters) for various sets of loblolly pine plots. Note that an RMSE of ~1.9 is quite close to recent estimates for much smaller areas: Erdody and Moskal (2010) reported an RMSE of 1.86 meters for tree heights using lidar, in pine forests (n=57)

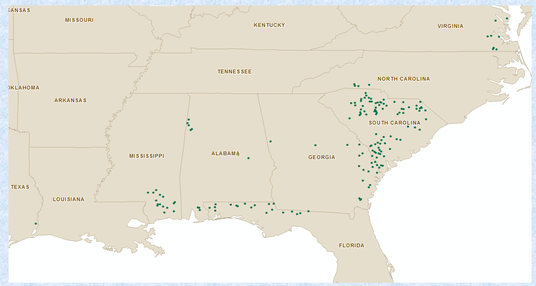

Figure 5: The location of the loblolly plots (n = 161)

Conclusions

- The RMSEs of our effort (~ 2.94 m) are lesser than that of other similar efforts, for large areas .
- Homogeneity of the plot (surrogate for co-registration accuracies), and species grouping (hardwoods versus softwoods) were found to be important factors for accuracy. Point density was relatively less important. We also estimated that ~33% of the RMSEs are caused by co-registration issues
- We selected a set of plots informed by our findings (homogeneity >= 10.0). These “better quality” plots had a significantly improved RMSE of 1.46 meters.
- For FIA plots dominated by managed loblolly pine, the RMSE is ~1.9 mts. This is comparable to similar attempts in literature.