Efficacy of using heterogeneous LIDAR datasets in generating a tree height map, over a large region

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Motivation: Why care about a tree height map?

- Estimation of biomass, for carbon accounting related to climate change
- Estimates of fuel load “hot spots”, where wildfire risk is high
- Canopy heights are important inputs when assessing forest health, in general, and in the context of global change

Previous work

1. Over a large area: There has been attempts to estimate tree heights over large areas using space-borne LIDAR sensors. The RMSE involved in these efforts varied from 5.0 to 12.5 meters (Lefsky et al 2005, Simard et al 2011).
2. For smaller areas: Most attempts are over similar Ecozones, and use the same airborne sensor. Relative RMSE of ~10% have been reported (Yu et al 2011).

Methods

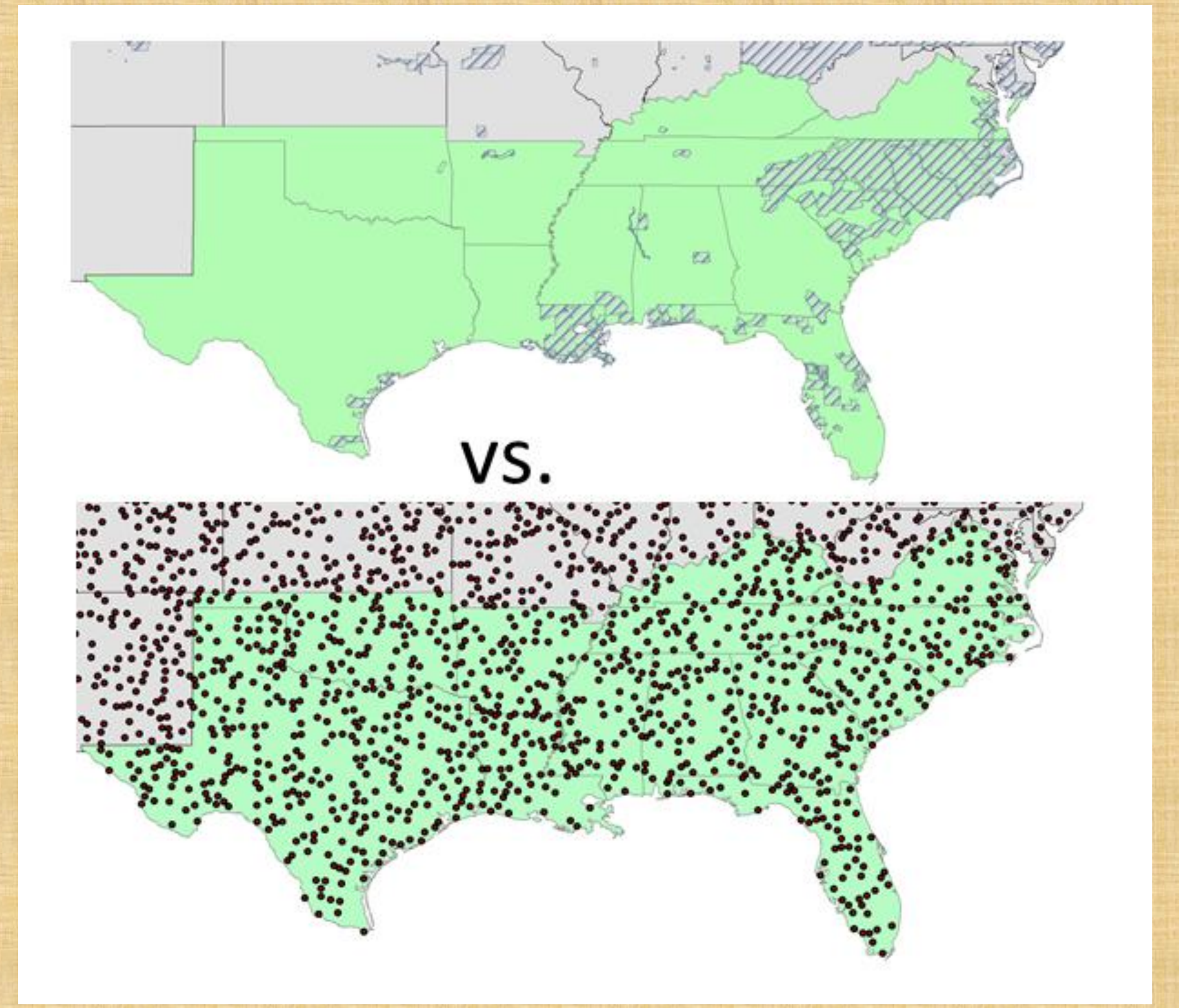

Fig 1: LIDAR coverage (top); a typical distribution of FIA field plots (bottom)

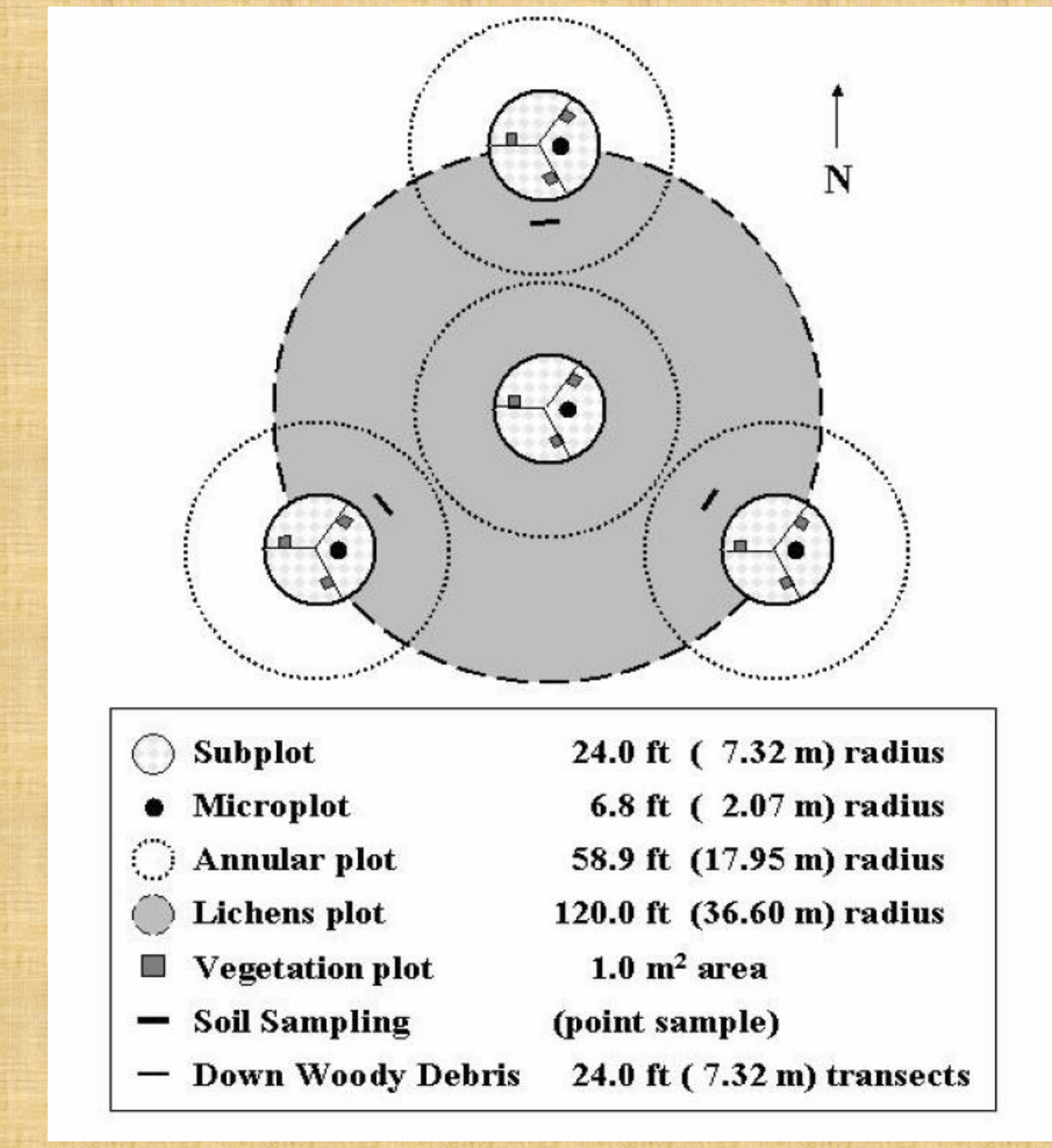

Fig 2: Layout of the FIA field plot

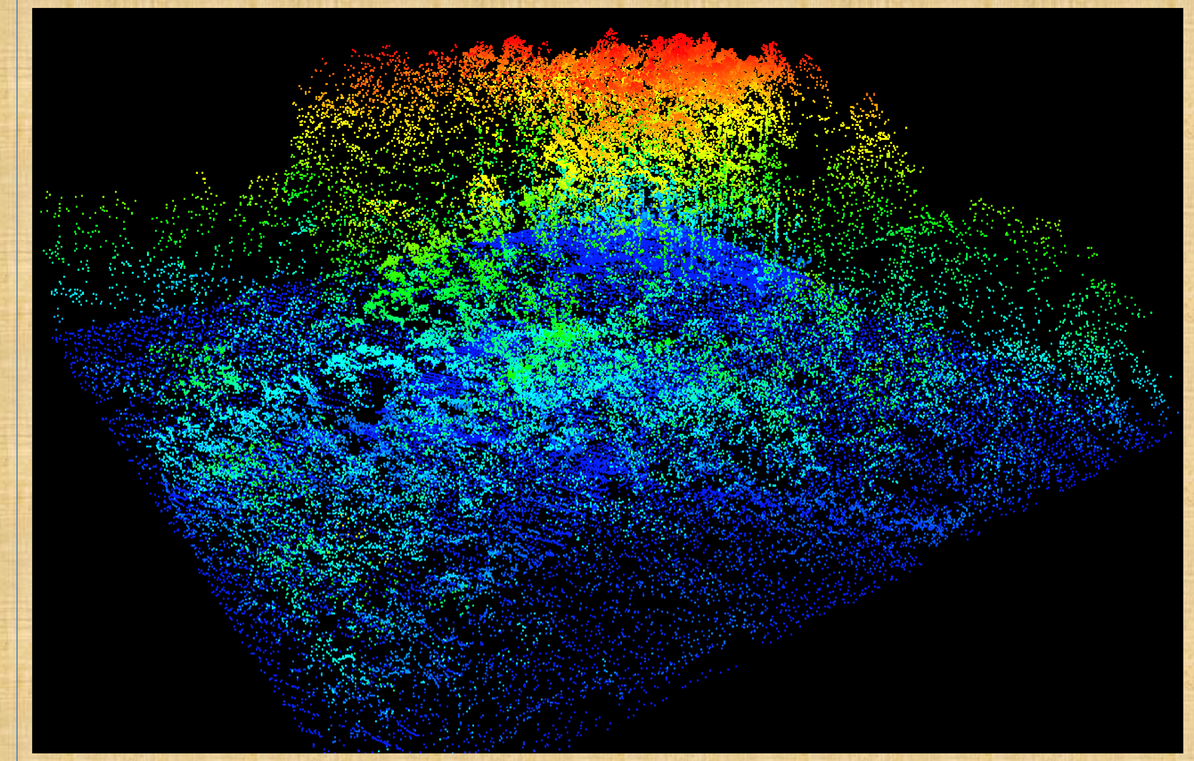

Fig 3: LIDAR point cloud distribution from a high point density acquisition in Georgia

- First, we got LIDAR data from USGS for a large area (fig 1), with LIDAR acquisition dates ranging from 2001 to 2011.
- Then, we intersected this data with FIA plot location data. This gave us ~4500 plots (square plots, 120 m) where we had both LIDAR and FIA field data.
- Then, simple linear regression models between the LIDAR parameters and FIA field measurements of tree heights, were made.

Results and conclusions

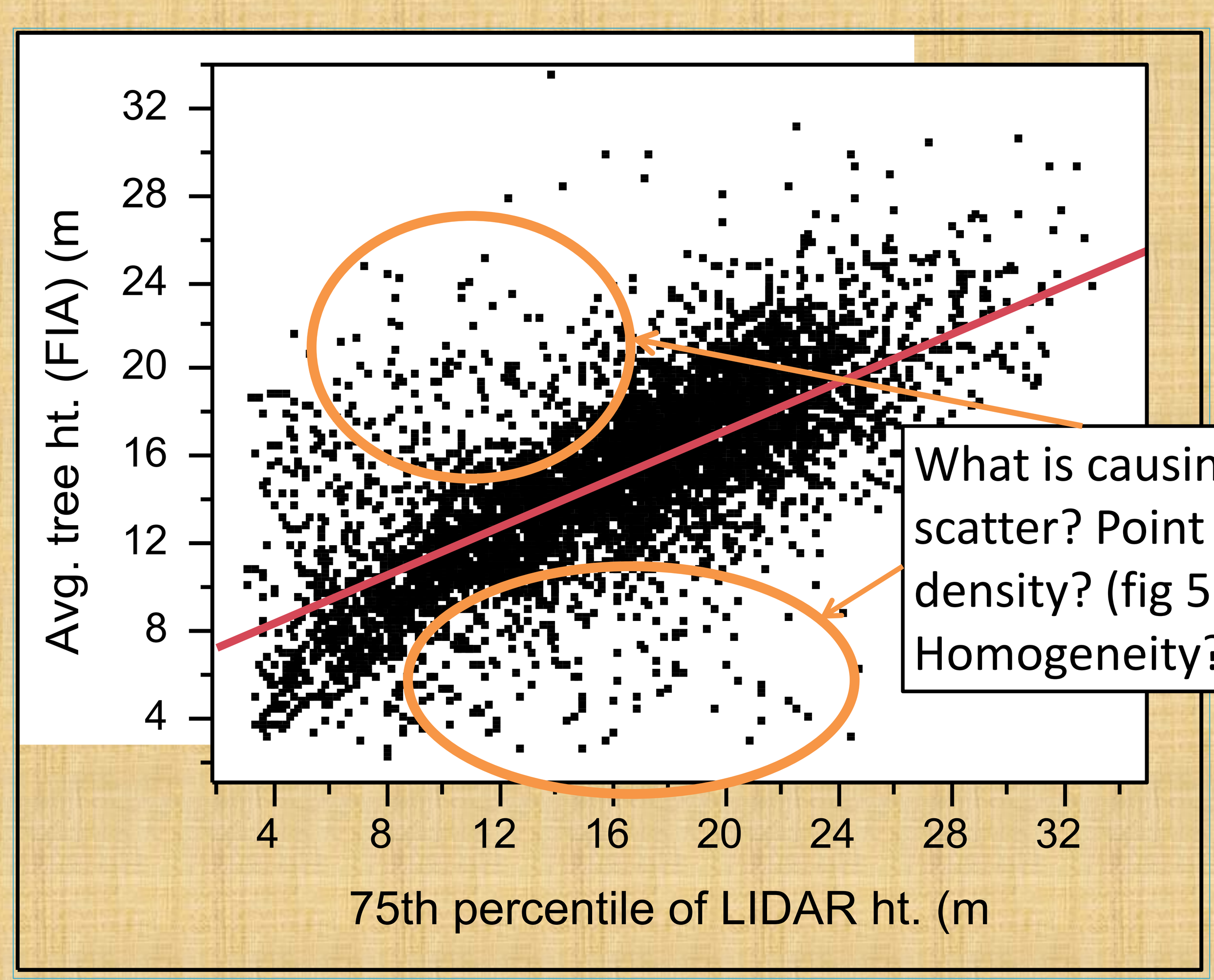

Fig 4: Simple linear regression fit of a LIDAR-based height metric, and the FIA-measured height. R^2 = 0.49, RMSE = 3.2 m, relative RMSE = 40%.

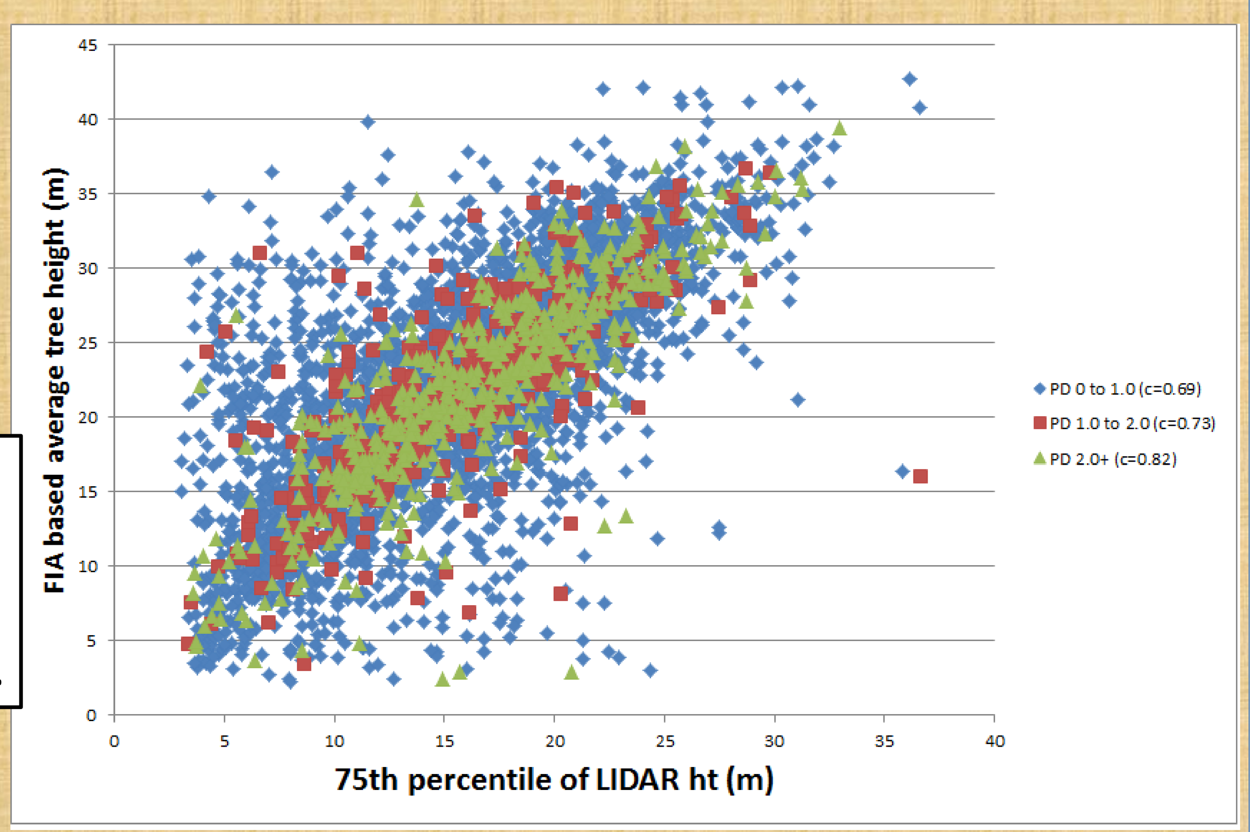

Fig 5: Variation in correlation (indicated as “c” in the legend) for various strata of point density (PD) of LIDAR returns (in num. returns/m^2). The advantage of high PD LIDAR data can be seen here.

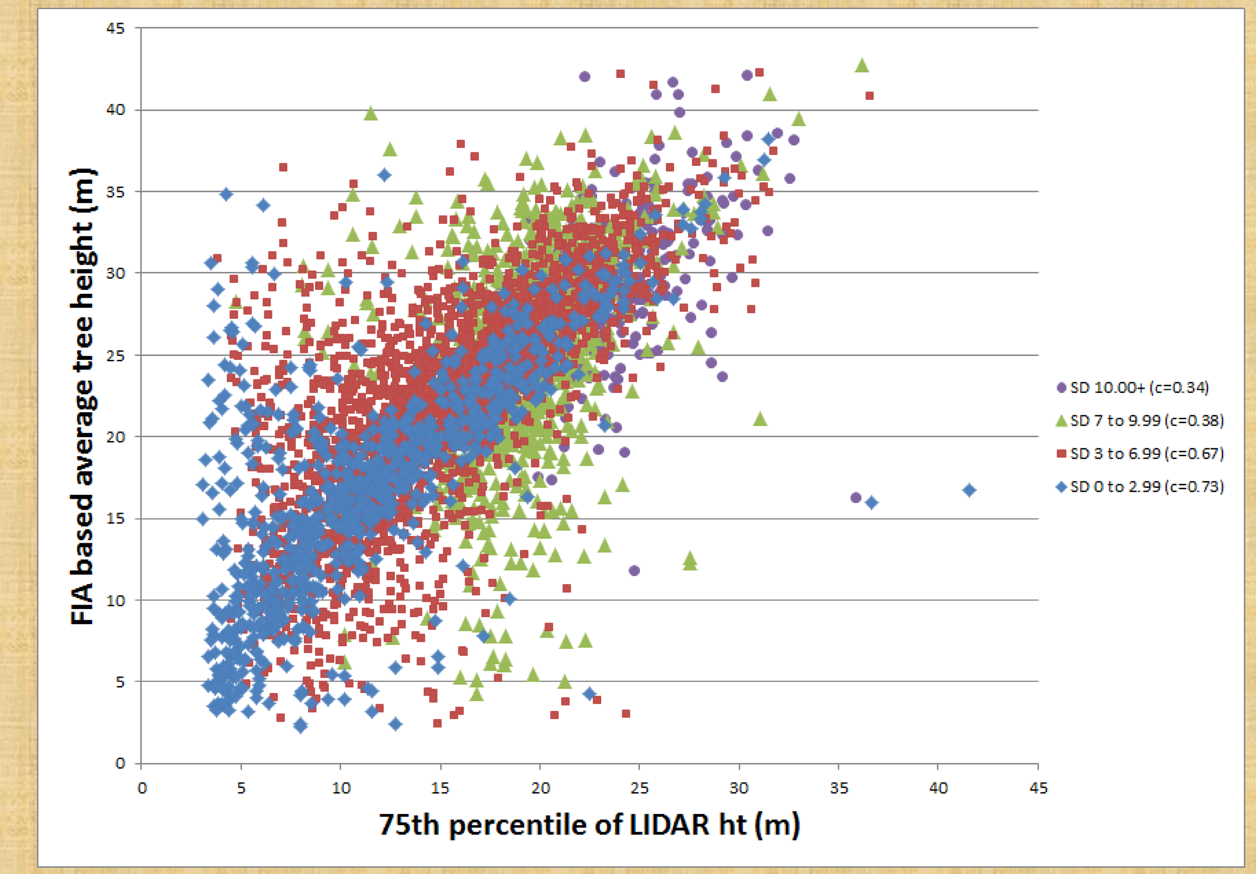

Fig 6: Variation in correlation for various homogeneity strata of plots. Here, homogeneity of vegetation heights over the square plots is represented by standard deviation (SD) of LIDAR heights.

Conclusions and future work

- The RMSEs of our effort (< 3.2 m) are lesser than that of other similar efforts, for large areas (>5.0 m).
- Point density of the LIDAR data and homogeneity of the plot (for vegetation heights) were found to be important factors, using CART analysis.
- Using point density and homogeneity, we screened out 1540 of the plots. The rest of the “better quality” plots had an improved RMSE of 2.8 meters (relative RMSE of 32%).
- Future work: 1) Work on a multivariate regression model factoring in point density, plot homogeneity and leaf-off/leaf-on conditions; 2) Extend this analysis to the understory, and ladder fuels.