Cartography of uncertainty of predicted forest variables estimated from ALS data

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Abstract

Linear regression is probably the most extended technique to predict forest attributes from Airborne Laser Scanner (ALS) data. It frequently happens that the model that minimizes the residual variance (Type 1 model) violates assumptions about the residuals that allow controlling the conditional uncertainty. In such situations arise a question about whether or not it is preferable to discard the Type 1 model and search for a new model which verifies the entire above mentioned hypothesis but with a higher residual variance (Type 2 models). By controlling the conditional variance it is possible to report uncertainty measures at pixel level as accuracy maps which can be of interest if decisions are involved at pixel scale. In this study we analyzed the differences of obtaining either regression models in which global accuracy is optimized or obtaining models in which uncertainty is fully controlled when predicting basal area (G), stand density (N), dominant height (Ho), mean tree height (Hm), standing volume (V), tree biomass (B) and quadratic mean diameter (Dg) from ALS data. Models of Type 1 and 2 were fitted for the above mentioned variables and their logarithms. The fitting was repeated 250 times for each variable using samples of 37 plots taken with replacement form the original set. The RMSE for models of Type 1 for G, N, Ho, Hm, V, and B were 2.08%, 9.97%, 2.97%, 11.43%, 3.80% and 5.20% lower than the RMSE for models controlling the conditional variance, Type 2.

1. Introduction

At the present, forest attributes are predicted from Airborne Laser Scanner (ALS) in operational applications that go beyond academic or research environments. Most of the applications of this technology to forest inventory have followed regression based approaches in which forest attributes are predicted from ALS-derived metrics. This method is usually referred as “Area Based Approach” (ABA), and it focuses on finding empirical relationships between ALS derived predictors and forest properties (Erdody and Moskal 2010, Maltamo et al. April 2006, Næsset 2002). Another type of approach sometimes called, “Individual Tree Approach”, has also been widely used with high density ALS data. This approach is based on finding trees in the ALS data and using these data for estimating the more interesting properties of the located trees (Hirata et al. 2009). Finally, a third way of deriving forest attributes from ALS data, that focuses on modeling the physical interactions between the forest canopies and the laser pulses has also been employed (Model Based Approach) (Magnussen et al. 1999, Mehtatalo and Nyblom 2012, Mehtatalo and Nyblom 2009).