Estimation of forest stem volume using ALS data and field data collected with relascopic technique

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Estimation of forest stem volume is important for forestry applications but also for environmental studies. Using remote sensing data, and in particular airborne laser scanning (ALS) data, gives the possibility to get results for large areas in a short time. The objective of this study is to estimate forest stem volume combining ALS data and field data collected with a relascope for a standard inventory in a forest area in the Southern Italian Alps. The motivation of using these field data instead of acquiring new data, was to save time and money and to investigate the possibility of using data collected for the ordinary forest management. The challenge of using these data is that for a standard forest inventory, the positioning accuracy of the GPS is not an important issue, whereas when it is necessary to combine these measurements with ALS data it is of vital importance. Therefore one goal of this study is to find out, if the use of field data collected for a standard inventory is reasonable for a research which includes ALS data. Based on the fact that it could be used, it is furthermore an objective to find out the optimal radius for the sample plots (in theory, the best size would be the one which cover the extent of the sample area taken by the relascope). In addition in this study we want to find out, if the stratification of the estimations according to forest stratum (categorized according to ecological criteria) improves the predictions of the forest stem volume.

To achieve these goals we adopted the processing chain presented in Figure 1. The ALS data were normalized by subtracting the Digital Terrain Model (DTM) from the absolute height a.s.l. of each ALS pulse (Tonolli et al. 2011a). A so called Canopy Height Model (CHM) was generated (see also Figure 1). For each field data point a buffer with a radius of 40 m was created. In the next step for each buffered area the ALS pulses from the CHM falling inside the circle were selected (Tonolli et al. 2011a). Furthermore circles with a radius (in m) of 10, 12.5, 15, 17.5, 20, 25, 30 and 35 were generated. Within these circles, 50 variables belonging to two categories, namely height and canopy density, were extracted for each laser return separately using the height distribution of the laser pulses. For the calculation only laser pulses with an elevation value higher than 2 m were considered (Tonolli et al. 2011b).

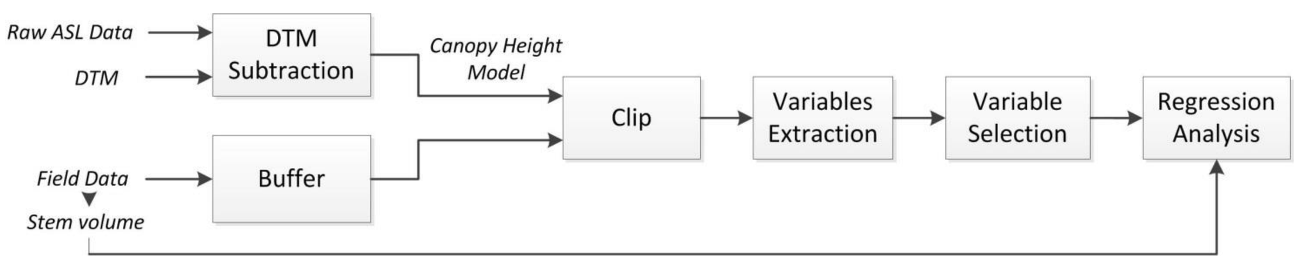

Figure 1: Processing scheme of the data processing for forest volume estimation

Based on a subset of these predictor variables a regression analysis was carried out to estimate the forest stem volume with a linear model, using the computed volume of the field data as the response variable. A stepwise selection was applied to determine the number of variables to be used in the *regsubset* function of the *leaps* R package (Tonolli et al 2011a). Using an ANOVA test, the best model (the one with the lowest possible number of predictor variables) was identified and used as regression model. For identifying the best suitable circle radius for the estimation of forest stem volume, the statistical value *adjusted-*R^2 was used.

The study area, characterized by a diverse structured forest with different kinds of forest species (e.g. Norway Spruce, Silver Fir, Larch and Silver Birch), is located in the Southern Italian Alps next to Pelizzano, a municipally in the Region of Trentino-Alto Adige. Distributed over an area of ca. 30 km^2, 365 field plots were collected between September and December 2012. The ALS data were acquired in September 2012 with an Optech sensor with a point density of at least 10 pts/m^2.

Given that the positioning accuracy of the field data had an error up to 10 m, the results of the estimated volume were poor (average adjusted-R^2 of 0.5). Nevertheless one of the outcomes of this study was, that using a circle of radius 15 m or radius 20 m were leading to better results then using an other radius. The regression analysis was not only computed for all the data but also for subsets of the data, and in particular for each forest stratum seperately. This resulted in a strong increasing of the adjusted-R^2 for some of the forest strata (the best adjusted R^2 for one of the strata using sample plots with radius of 15 m was around 0.9) and in a decreasing for some other (worst adjusted-R^2 = 0.4).

In the future we plan to conduct further anlaysis in order to understand better the role of the GPS positioning accuracy.

References

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