Multispectral LiDAR data for the prediction of forest stand attributes

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In this study, the potential of the Optech Titan multispectral LiDAR data to model and predict forest attributes at plot level is explored. In particular, we focus on four attributes: the aboveground biomass (AGB) per hectare (*AGBha*), the Gini coefficient of the diameter at breast height (*GiniDBHs*), and the Shannon diversity index of the tree species (*SDI*).
The study area is located in the Hadeland municipality in Southern Norway. The field data were collected on seven circular sample plots of size 1000 m^2 and two circular sample plots of size 500 m^2. In order to have a larger number of plots for the analysis the plots were split in 32 subplots of 250 m^2. For each subplot AGB per hectare (*AGBha*), the Gini coefficient of DBHs (*GiniDBH*), the Shannon diversity index (*SDI*), and the number of trees per hectare (*Nha*) were computed.
LiDAR data were acquired with an Optech Titan sensor on the 27th of April 2016. Up to four echoes per pulse were recorded and the resulting density of single and first echoes was 38 pts/m2 (14 pts/m2 for the 1550 nm channel, 21 pts/m2 for the 1064 nm channel, and 3 pts/m2 for the 532 nm channel).
The normalized Z, i.e. heights above ground, was computed for the LiDAR data, and the intensity value of each LiDAR point was range calibrated. From each subplot variables (e.g. maximum, minimum, percentiles) were extracted from the point cloud, and five sets of variables were defined: i) TITAN: variables extracted considering the points altogether; ii) TITAN_1_2_3: variables extracted considering separately the points of the three LiDAR channels. In this way each variable was extracted three times; iii) TITAN_1: variables extracted only from the first channel (1550 nm); iv) TITAN_2: variables extracted only from the second channel (1064 nm); v) TITAN_3: variables extracted only from the third channel (532 nm). Multiple linear regression analysis was adopted.
The most accurate model for the *AGBha* prediction was the TITAN_1_2_3 (R^2 =0.9), for the *GiniDBHs* the TITAN_2 (R^2=0.79), and for the *SDI* the TITAN (R^2=0.89). The TITAN_3 model has always the lowest R^2. Not all the channels provide the same amount of information, and the multispectral information is not always used. In particular, for the *AGBha* models it seems that the elevation information is much more useful. In contrast, the intensity information is frequently used for *SDI*. The 532 nm channel provided the weakest results for all the considered target variables.