How much does the range correction of LiDAR intensities improve tree species discrimination?

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Estimating stand attributes by tree species is a key task in forest inventory. Remote sensing is used today increasingly. Typically, airborne laser scanning (ALS) data is combined with aerial images when species-specific attributes are needed. The role of aerial images is to improve species discrimination. A new ALS instrumentation, multispectral LiDAR, has been suggested as a single sensor solution to species-specific inventory. The main idea is to use LiDAR intensities instead of spectral information of aerial images to improve species discrimination.

We investigate range correction of LiDAR intensities with Optech Titan multispectral ALS data. The experiment was conducted in Eastern Finland using 479 sample plots distributed systematically to the study area. The scanning setup resulted in a 55% overlap of flight lines, which means that every sample plot is visible at least from two flight lines. In an ideal case, the observed plot level mean intensity from different flight lines should be similar. This is the goal of intensity correction. We examine range correction, because is it widely used approach and does not require the use of reflectance targets, which is impossible in operational projects. The correction is based on the radar equation having origins the field of microwave radar. Range correction is a simplified form of radar equation, which – as its name suggests – normalizes intensities for a range with respect to a reference range:

$$I_{corrected} = \left(\frac{Range}{Range_{reference}}\right)^{f} * \ I_{original} \ ,$$

where $Range$ is the distance from the ALS device to the target, $Range_{reference}$ is the mean range, I refers to original and corrected intensities, and *f* is the tuning parameter. The theory suggests that for targets larger than pulse's footprint (e.g. ground) *f* is 2.0. A 2006 ISPRS paper by Wagner et al. presents a theoretical justification of why *f* cannot be smaller than 2.0. When target is a tree crown where branches, leaves or shoots are smaller than pulse's footprint the *f* should be larger than 2.0. In the prediction of tree species, echoes reflecting from trees crowns instead of ground are of interest. This poses two questions: (1) do we get significant improvement from the range correction and (2) what is the optimal *f* value? We evaluated the effect of intensity correction for tree species discrimination with different strategies to define *f* parameter.

Our results show that the benefit of intensity calibration is quite modest and the *f* values minimizing plot level intensity difference between flight lines do not necessarily lead to the best tree species discrimination. We also observed that the *f* values minimizing plot level intensity differences were below 2.0 in all channels, which is against the theory. This indicates that range correction is sub-optimal method for canopy echoes or that the ALS device modifies intensities some way.