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Airborne Laser Scanning - based vegetation classification in grasslands: a feasibility study

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Airborne Laser Scanning is traditionally used for topography mapping, exploiting its ability to map terrain elevation under vegetation cover. Parallel to this, the application of ALS for vegetation classification and mapping of ecological variables is rapidly emerging. Point clouds surveyed by ALS provide accurate representations of vegetation structure and are therefore considered suitable for mapping vegetation classes as long as their vertical structure is characteristic. For this reason, most ALS-based vegetation mapping studies have been carried out in forests, with some rare applications for shrublands or tall grass vegetation such as reeds.

The use of remote-sensing derived vegetation maps is widespread in ecological research and is also gaining importance in practical conservation. There is an increasing demand for reliable, high-resolution datasets covering large protected areas. ALS can provide both the coverage and the high resolution, and can prove to be an economical solution due to the potential for automatic processing and the wide range of uses that allows spreading costs.

Grasslands have a high importance in nature conservation as due to the drastical land use changes (arable lands, afforestation, fragmentation by linear structures) in the last centuries the extent of these habitats have been considerably reduced. Among the habitat types protected by the Habitat Directive of the Natura 2000 system, several grassland habitat types (e.g. hay meadows, dry grasslands harbouring rare Orchid species) have special priority for conservation. For preserving these habitat types application of a proper management - including mowing or grazing – has a crucial role. Therefore not only the mapping of the locations of habitats but the way of management is needed for representing the natural processes.

The objective of this study was to test the applicability of airborne laser scanning for ecological vegetation mapping in and around grasslands.

The study site is situated in the Sopron mountains (Western Hungary), in the Soproni-hegység Natura 2000 site which has an area of 52 km2 protected under Natura 2000. While the Natura 2000 site is dominated by forests, it also holds several grassland habitats: lowland and mountain hay meadows, dry grasslands, fringe communities and disturbed secondary grasslands in the forest clearings. In the framework of the Changehabitats2 project, ALS surveys of the area were carried out, under leaf-on conditions in July 2012 and March 2011, with a full-waveform sensor (Riegl LMS-Q680i) operating at 1550 nm. The resulting point density was 12.8 echoes/m2. 10 grasslands were selected from the study site varying in size between 0.1 and 3 km2. The ALS datasets of these sites were processed in OPALS software to a set of rasters representing different variables of the leaf-on and leaf-off point cloud, each with a raster size of 0.5 m * 0.5 m. Echo amplitude for single echoes was calibrated to reflectance using estimated reflectivity of an asphalt surface. A Digital Terrain Model was created using hierarchical robust filtering in SCOP++ software, and normalized digital surface models were calculated by subtracting this from the local surface models. Echo width and surface roughness were also calculated in OPALS. Surface openness was measured in order to distinguish circular and linear features, such as sedge clumps and ploughing marks. Finally, all these rasters were stacked in ENVI software, resulting in a pseudo-image, where each pseudo-channel corresponded to a different ALS-derived variable.

Reference datasets were collected in the field using differential GNSS. Habitat type, dominant vegetation species and other features of interest were noted in the point attributes, and a set of 90 circular plots was recorded. These were overlain on the pseudo-image to create regions of interest (ROI), resulting in 100-4000 ROI pixels for each vegetation category.

Multivariate statistics were then used in order to analyse the trends in the data: interdependence of the ALS-derived variables was tested by calculating covariance matrices and the separability of the vegetation categories was tested by the Jeffries-Matusita index. The results of the multivariate analysis were used for merging and excluding classes from the initial 24 to find those where the accuracy was sufficient and the results were relevant for conservation.

Results show that a large number of variables can be derived from leaf-on and leaf-off ALS surveys that are statistically independent from each other and thus provide a good basis for classification. With appropriate calculation methods, a number of pseudo-bands comparable to multispectral imagery can be reached. These categories are of course not equally relevant for vegetation mapping. Not surprisingly, the categories with the strongest separability are those closely linked to vegetation height or texture. Mown grasslands can be well separated from abandoned grasslands; tussock-forming grasses from more uniform textured tall herbs. While quality control is still in progress and the trade-off between the number of categories and the classification accuracy is evident, it is expected that for a limited range of vegetation classes, the reliability of the method will be comparable to passive optical image processing.

Using a classification method slightly different from the conventional ALS-based vegetation mapping approach, encouraging results have been obtained for an area where the vertical structure of the vegetation is limited. The present state of the art of ALS sensors including full waveform processing and calibration of surface reflectance allows vegetation mapping even in grasslands. It is expected that the further development of waveform digitization and the ever-increasing scanning frequencies will further support such studies in the future.