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Analysis of airborne LiDAR as a basis for digital soil mapping in Alpine areas

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Especially in mountainous regions like the Alps the formation of soil is highly influenced by relief characteristics. Among all factors included in Jenny's (1941) model for soil development, relief is the one most commonly used in approaches to create digital soil maps and to derive soil properties from secondary data sources (McBratney et al. 2003). Elevation data, first order (slope, aspect) and second order derivates (plan, profile and cross-sectional curvature) as well as complex morphometric parameters (various landform classifications, e.g., Wood 1996) and compound indices (e.g., topographic wetness indices, vertical distance to drainage network, insolation) can be calculated from digital elevation models (DEM). However, while being an important source of information for digital soil mapping on small map scales, "conventional" DEMs are of limited use for the design of large scale conceptual soil maps for small areas due to rather coarse raster resolutions with cell sizes ranging from 20 to 100 meters. Slight variations in elevation and small landform features might not be discernible even though they might have a significant effect to soil formation, e.g., regarding the influence of groundwater in alluvial soils or the extent of alluvial fans.
Nowadays, Airborne LiDAR (Light Detection And Ranging) provides highly accurate data for the elaboration of high-resolution digital terrain models (DTM) even in forested areas. In the project LASBO (Laserscanning in der Bodenkartierung) the applicability of digital terrain models derived from LiDAR for the identification of soil-relevant geomorphometric parameter is investigated. Various algorithms which were initially designed for coarser raster data are applied on high-resolution DTMs. Test areas for LASBO are located in the region of Bruneck (Italy) and near the municipality of Kramsach in the Inn Valley (Austria). The freely available DTM for Bruneck has a raster resolution of 2.5 meters while in Kramsach a DTM with a cell size of 1 meter is used.

Firstly, morphometric analyses are carried out using the open-source GIS-software packages SAGA (System for Automated Geoscientific Analyses) and GRASS (Geographic Resources Analysis Support System). In a next step, an object-based image analysis with the commercial software Definiens Professional is used to classify the different terrain parameters based on fuzzy membership functions. Further information on geology and land use are also integrated to optimize the results of the classification. Besides the distribution of soil units, basic soil parameters like horizon or solum depth and groundwater influence ("gleysation") will be modelled to reassess the full potential of DTMs derived from LiDAR for digital soil mapping of mountainous regions.
First attempts show that a very high raster resolution makes it difficult to differentiate between actual changes of elevation and minor differences between raster cells which mainly remained after DTM filtering, or are caused by the interpolation of point data. Eliminating errors in the DTM is difficult and needs manual interaction to avoid a general loss of significant information. Various concepts are combined to achieve an optimised balance between the highest possible accuracy and a minimal loss of information. Different resampling methods and filter techniques are used to modify the original data in order to capture relief features and soil properties at different scales. The results finally are verified using aerial photographs, existing soil maps and field mapping of soil and geomorphologic features. DTMs with a coarser resolution of 10 meters (Kramsach) and 20 meters (Bruneck) respectively generated with photogrammetric methods are also used to compare the results and estimate the chances and limitations of DTMs derived from LiDAR for digital soil mapping.