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Measuring microtopography with Terrestrial Laser Scanning: Aspects of data quality

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The availability of Terrestrial Laser Scanning (TLS) equipment gives the opportunity to study soil surface parameters to a degree of detail that was previously limited to laboratory trials. For field studies, knowledge of soil microtopography is required when parameters such as soil roughness, surface storage and runoff connectivity are concerned. TLS provides a non-destructive means to conduct multi-temporal measurements of microtopography. The suitability of this type of scanner for measurements, however, has not been assessed systematically. The objective of this research was to determine whether TLS measurements yield reasonably accurate Digital Terrain Models (DTM) at relatively high resolutions (0.02 to 0.20 m) and to identify, and possibly quantify, the limitations.

For this purpose, two large plots of 100 m^2 and one smaller plot of 20 m^2 were scanned with a Leica ScanStation 2. The plots are situated in Southern Norway, and are used for wheat cultivation. The plots represented three tillage operations that are typical in autumn in the study area. One of the large plots was mouldboard ploughed, the other not tilled at all and the small plot was newly sown.

Scans from different viewpoints were required to ensure that the plots were fully covered; the large plots required at least 15 viewpoints and for the smaller farm plot four was enough. The point clouds from the different viewpoints were merged and cropped to create the terrain models. A filter was used to eliminate non-terrain points (mostly crop residue and young wheat stands). The surfaces were de-trended for soil roughness calculations by means of a pseudo-planar routine for roughness calculations.

Coverage was calculated as the ratio of grid cells that had at least one measurement after filtering. In the absence of a reference soil surface model the accuracy of the measurements cannot be assessed directly. Instead, grid cell averages calculated separately for different viewpoints were compared with a Welch t-test. The ratio of cells that had significantly different averages between viewpoints was used as an indicator for accuracy. All calculations were undertaken at spatial resolutions from 0.02 to 0.20 m.

It was found that coverage is generally good for the scanned surfaces. Except for the mouldboard ploughed surface at resolutions 0.02 m, coverage was well over 95%. Accuracy was generally good for all three surfaces at grid resolutions of 0.02 and 0.03 m, with ratios of significantly different grid cell elevation values of 1.5 to 5.5%. This, however, quickly deteriorated at lower resolutions. Further investigation showed that aspect, or surface orientation relative to the scanner, in combination with scanner distance explained differences in average grid cell elevations to some degree, but not fully.

TLS is capable of accurately measuring soil microtopography at high resolutions, given measurements are taken from ample viewpoints and point clouds are post-processed properly. The range of applicability however is limited by three factors: soil roughness, the presence of non-surface objects and proximity of the scanner to the object. TLS is not an option on very rough surfaces if measurements cannot be done from near by, or indeed elevated viewpoints. The presence of weeds and plants severely constrains the use of the technology.