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Assessment of terrestrial laser scanner and close range photogrammetry for characterizing surface roughness in agricultural soils

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Soil surface roughness is a variable that represents the microtopographic variations of soil surface elevation and as such, it is a key element in the hydrological and erosive behavior of soils. In agricultural soils, surface roughness is mainly an anthropic factor determined by the type of tillage and soil management. In order to quantify surface roughness and to parameterize its role in different processes, different measurement techniques have been proposed in the literature. The objective of this work is to evaluate different measurement techniques and to assess their accuracy and suitability for quantifying surface roughness in agricultural soils.

With this aim, a comparative analysis of three different measurement techniques was carried out; (1) laser profilometer, (2) terrestrial laser scanner and (3) close-range photogrammetry. Three experimental plots (5 x 5 meters) were measured representing different roughness conditions: high roughness (mouldboard plough), medium roughness (chisel) and low roughness (mouldboard plough + harrowed compacted). For each experimental plot: 8 profiles (4 in parallel and 4 in perpendicular to the tillage direction) were obtained with the laser profilometer; 4 scans (one for each side of the plot) were measured using FARO Focus 3D; and 30-40 RGB photographs were taken with a Canon EOS 5D Mark II camera from a height of 5-10 m above ground.

A specific algorithm was developed to filter erroneous measurements (mixed pixels) in raw terrestrial scanner data. The filter was implemented in the software OPALS (Orientation and Processing of Airborne Laser Scanning data), and the amount of filtered points was different for each experimental plot. The digital images were oriented and processed in Agisoft PhotoScan software. The laser profilometer data were processed with Matlab. The co-registration of point clouds derived from terrestrial laser scanner and close-range photogrammetry was done with a version of the iterative closest point (IPC) algorithm implemented in the OPALS software.

The results showed a very good co-registration (the standard deviation of point-to-plane distance was $\sim$2 mm) of the different point clouds obtained. The profiles measured with the profilometer were in agreement with the profiles derived from the point clouds. However, some differences could be observed in the values of the roughness parameters calculated. More precisely, the standard deviation of heights (s) was underestimated ($\sim$5%) and the correlation length (l) was overestimated ($\sim$10%) in close-range photogrammetry and laser scanner techniques in comparison to the laser profilometer. All in all, both techniques, terrestrial laser scanner and close-range photogrammetry, appeared to be accurate enough for soil surface roughness characterization.