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Comparative analysis of different measurement techniques for characterizing soil surface roughness in agricultural soils

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Soil surface roughness can be defined as the variation in soil surface elevations, and as such, it is a key element in hydrology and soil erosion processes. In agricultural soils, roughness is mainly an anthropic factor determined by the type of tillage and management. Roughness is also a property with a high spatial variability, since the same type of tillage can result in surfaces with different roughness depending on the physical characteristics of the soil and atmospheric conditions. In order to quantify roughness and to parameterize its role in different processes, different measurement techniques have been used and several parameters have been proposed in the literature. The objective of this work is to evaluate different measurement techniques and assess their accuracy and suitability for quantifying surface roughness in agricultural soils.

With this aim, a comparative analysis of three roughness measurement techniques has been carried out; (1) laser profilometer, (2) convergent photogrammetry and (3) terrestrial laser scanner. Roughness measurements were done in 3 experimental plots (5x5 meters) with different tillage treatments (representing different roughness conditions) obtained with typical agricultural tools. The laser profilometer registered vertically the distance from a reference bar down to the surface. It had a vertical accuracy of 1.25 mm, a sampling interval of 5 mm and a total length profile of 5 m. Eight profiles were taken per plot, four in parallel to tillage direction and four in perpendicular. Convergent photogrammetry consisted of 20-30 images taken per plot from a height of 5-10 m above ground (using an elevation platform), leading to point clouds of ∼25 million points per plot. Terrestrial laser scanner measurements were taken from the four sides of each plot at a measurement height of ∼1.75 m above ground. After orientating and corregistering the four scans, point clouds of ∼60 million points were obtained per plot.

The comparative analysis was threefold: (1) comparison of raw data (point clouds), (2) comparison of interpolated DEMs considering different resolutions (2.5mm, 5mm and 10mm) and (3) comparison of roughness parameters. In all cases the profilometer was used as a reference because of its vertical accuracy and nadiral viewing geometry. Thus point clouds and interpolated DEMs were compared to the height profiles. The results showed that in most cases surface height discrepancies were below 10 mm for raw data and increased slightly when increasing the pixel size of DEMs. Finally, a thorough analysis of different roughness parameters proposed in the literature was carried out to find the most appropriate technique and parameter for the characterization of roughness in each case. Although still preliminary, results offer practical recommendations on the usefulness of each technique.