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Assessing soil surface roughness using reflectance band indices obtained with an airborne multispectral sensor at very high spatial resolution

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Surface processes like water and wind erosion, and water vapour and CO2 diffusion in natural and agricultural soils are strongly influenced by soil surface roughness (SSR). SSR is often measured using non-contact methods such as laser profilers or scanners, digital close range stereo-photogrammetry and terrestrial laser scanning or LIDAR systems. These methods however lack the potential to conveniently assess SSR over larger areas like the plot or field scale size.

Numerous investigations on soil reflectance characteristics in the optical wavelength region showed that the single most important factor influencing the observed bidirectional soil reflectance anisotropy is soil surface roughness. Thus, in principle optical remote sensing methods have the potential to provide useful quantitative information on SSR. The possibility to assess SSR by means of correlating measured reflectance data at different wavelengths and under different illumination and viewing angles has been successfully demonstrated at extremely fine spatial scales (mm) using sieved soil materials and hyperspectral data.

We present here results of a study aimed at investigating if a similar approach can be applied to larger field or plot scales under operational conditions using very high spatial resolution multispectral imagery (12.5cm) acquired at different sun angles. For this aim, airborne imagery was acquired over two study sites with the narrow-band multispectral ADC sensor (Tetracam Inc., USA) onboard an unmanned aerial vehicle (UAV) platform at wavelengths 550, 670 and 800nm. The imagery was then corrected to at-ground reflectance after geometric, radiometric calibrations and atmospheric correction.

The first study site was an experimental field (100x40m) on which different roughness levels were obtained by applying five conventional tillage methods on different subplots and imagery acquired at four different times of the day. The second study site was a large olive orchard with trees planted at 7.5x5.0m and bare soils between rows. Three tillage treatments were applied on two separate blocks within the orchard. For this site, the imagery was acquired only at two different times of the day due to the shadow cast on the soil by the olive trees. A laser-scanning instrument was used to obtain representative digital elevation models (DEMs) for each treatment with a grid resolution of 7.2x7.2mm over an area of 0.9x0.9m. Four roughness indices (standard deviation, the tortuosity indices T_A and T_B, mean surface slope) were calculated for each DEM as quantitative descriptors of SSR. For each DEM location, reflectance data was extracted from the corrected reflectance imagery and a suite of several spectral band indices calculated.

Simple linear regression and correlation analysis was used to investigate the relationship between the spectral band indices and the quantitative roughness indices quantitative roughness indices extracted from the field measured DEMs on both site. Meaningful prediction models were obtained, suggesting the potential of this methodology for obtaining quantitative estimates of soil surface roughness over larger field sites.