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Characterising soil surface roughness using a combined structural and spectral approach

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This paper describes the results of an experiment designed to investigate whether hyperspectral directional reflectance factors can be used to describe fine-scale variations in soil surface roughness. A Canadian silt loam soil was sieved to an aggregate size range of 1-4.75 mm and exposed to five different durations of artificial rainfall to produce soil states displaying progressively decreasing levels of surface roughness. Each soil state was measured using a point laser profiling instrument at 2 mm spatial resolution, in order to provide information on the surface structure and spatial arrangement of soil particles. Hyperspectral directional reflectance factors were measured using an Analytical Spectral Devices FieldSpec Pro instrument (range 350-2500 nm), with reference to a calibrated Spectralon panel. A broad range of measurement angles were used (r = -60º to +60º) in the solar principal plane; with a wide range of illumination angle conditions (i = 28º to 74º). Directional reflectance factors were found to vary with illumination and view angles, and according to the soil state. Geostatistically-derived indicators of soil surface roughness (sill variance) were then used as the basis for linear regression with directional reflectance factors. The results showed a strong relationship between directional reflectance factors and surface roughness (R2 = 0.94 where r = -60º, i = 67º-74º). This fine-scale quasi-natural experiment allowed the control of slope, initial aggregate size and rainfall exposure. This permitted an investigation into the nature of interaction between specific factors affecting the reflectance distribution; highlighting the importance in understanding fine-scale variations in surface roughness and particularly illumination angle. The results of the paper suggest that this technique could prove useful for providing a quantitative measure of surface roughness at fine spatial scales.