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Field-scale estimation of rock content in stony soils from electrical resistivity measurements

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Stony soils, i.e. soils containing more than 35% of rock fragments, cover large areas: more than 30% of European soils are considered as stony soils and this proportion reaches 65% in Mediterranean areas. Nevertheless, the hydric properties of stony soils are still difficult to estimate for two reasons: on the one hand, the basic properties of stones, like their water retention characteristics for example, are usually unknown, and, on the other hand, the real percentage of stones in a given soil is difficult to estimate. We address here the second point and present a methodology that will help in determining the quantitative proportion of stones at field scale - over few hectares - by using spatial electrical resistivity measurements. The assumption is that electrical resistivity is highly sensitive to the stone content. Indeed, firstly, the direction of the electrical current lines is highly modified by stones and the soil behaves as a very heterogeneous porous medium, which leads to high uncertainties in the inversion of electrical resistivity data. Secondly the contact of electrodes with the soil can be faulty and the injection of current can be then strongly disturbed when the soil surface is stony. As a consequence, the resulting electrical resistivity signal can contain a high level of noise.

To test this hypothesis, electrical resistivity measurements were performed on several small heterogeneous parcels (approximately 2 to 10 ha area), each one encompassing soils with different stone contents. Measurements were realised with the ARP (Automatic Resistivity Profiling) device that is composed by three arrays in V-shaped configuration: each array is composed by four electrodes-wheels, i.e. two electrical current electrodes spaced 1 m apart, and two resistivity electrodes spaced of –respectively for each array- 0.5 m; 1m; 1.7m apart. This device can therefore cover a large area in a short time and measure the electrical resistivity at field scale with a high spatial resolution.

In addition, direct measurements of stones contents were realised in field on large volumes of soils sampled in several pits. In the studied areas, the stone contents varied then from less than 20% to more than 50% in stone content. By comparing the resistivity noise to the stone contents, we have shown a significant and linear correlation between both variables. This relationship was calibrated from several points within one parcel and validated at other locations. It was then used for stone content mapping at field scale. Additional analyses have enabled us to discuss the main limits of the approach: i) electrical resistivity measurements should be recorded rather in a dry period and ii) stone contents less than 20 % in volume can not be estimated and mapped.

Finally, from the local estimation of stone contents and the water retention properties of both stones and the fine earth, the Available Water Content was calculated at the field scale. We demonstrated that it can vary of several millimetres for a given parcel, due to the local stone content, which indicates that water management, especially irrigation, at the parcel scale must be conducted by taking into account the variability due to the presence of stones.

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