Geophysical Research Abstracts
Vol. 20, EGU2018-11705, 2018
EGU General Assembly 2018

Using large scale ERT in the critical zone to disentangle regolith properties and architecture: on the role of electrode spacing

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Regolith architecture and properties are key to streamflow generation. An accurate assessment of the geometry and properties of the main compartments of the regolith is of major relevance in hydrological studies. Factors such as the composition of the soil cover, the soil depth, and the weathering state and features of the subsoil, determine water infiltration and percolation pathways, water residence times, as well as its subsequent interactions with surface water bodies. However, the complexity and spatial variability of the subsurface structure of the regolith make its characterisation very challenging. In this context, Electrical Resistivity Tomography (ERT) is now a well-established and commonly used method in hydrological studies to grasp the spatial variability of subsurface properties. This technique eventually allows to overcome the limited spatial resolution of the conventional “point-scale” drilling approach. In many cases, though, the subsurface structure is shallow and has to be investigated with a precise vertical scale, requiring a small unit of electrode spacing (UES). Under these circumstances, ERT measurements remain time-consuming. Contrariwise, when the aim is to carry out large horizontal surveys, a set-up with larger UES is preferred.

In this study, we place the emphasis on the importance of the UES parameter to correctly decipher the regolith’s compartmentalization and reduce the ill-posed inverse problem effect. To this end, we investigate a synthetic three layer soil–saprock/saprolite–bedrock system by varying their resistivity and thickness contrasts and using a classical geophysical approach based on numerical modelling to compute apparent resistivity. After Inversion, we compared ERT distributions obtained for different UES with synthetic true resistivity models. We also derived interfaces depths using a derivative method and evaluated their accuracy with respect to true depths. A field dataset was then used to corroborate the numerical findings.

Our results show that the chosen UES is critical for having a representative interpreted resistivity distribution. It has to be selected while considering the thickness of the subsurface top layer. If a larger UES is retained, the accuracy decreases abruptly in terms of both resistivity distribution and interfaces delineation. And this finding is valid both for the shallow part of the subsurface and for the deeper horizons. We also demonstrate that the addition of surficial apparent resistivity interpolated levels based on a limited number of ERT profiles with a small UES, results in an improved accuracy of ERT profiles with a large UES. This finding can be valuable for carrying out large scale surveys in a cost-effective and more robust way.