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Improving water content estimation on landslide–prone hillslopes using structurally–constrained inversion of electrical resistivity data

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Rainfall-triggered landslides are a latent danger in almost any place of the world. Due to climate change heavy rainfalls might occur more often, increasing the risk of landslides. With pore pressure as mechanical trigger, knowledge of water content distribution in the ground is essential for hazard analysis during monitoring of potentially dangerous rainfall events. Geophysical methods like electrical resistivity tomography (ERT) can be utilized to determine the spatial distribution of water content using established soil physical relationships between bulk electrical resistivity and water content. However, often more dominant electrical contrasts due to lithological structures outplay these hydraulic signatures and blur the results in the inversion process. Additionally, the inversion of ERT data requires further constraints. In the standard Occam inversion method, a smoothness constraint is used, assuming that soil properties change softly in space. This applies in many scenarios, as for example during infiltration of water without a clear saturation front. Sharp lithological layers with strongly divergent hydrological parameters, as often found in landslide prone hillslopes, on the other hand, are typically badly resolved by standard ERT.

We use a structurally constrained ERT inversion approach for improving water content estimation in landslide prone hills by including a-priori information about lithological layers. Here the standard smoothness constraint is reduced along layer boundaries identified using seismic data or other additional sources. This approach significantly improves water content estimations, because in landslide prone hills often a layer of rather high hydraulic conductivity is followed by a hydraulic barrier like clay-rich soil, causing higher pore pressures. One saturated layer and one almost drained layer typically result also in a sharp contrast in electrical resistivity, assuming that surface conductivity of the soil does not change in similar order. Using synthetic data, we study the influence of uncertainties in the a-priori information on the inverted resistivity and estimated water content distribution. Based on our simulation results, we provide best-practice recommendations for field applications and suggest important tests to obtain reliable, reproducible and trustworthy results. We finally apply our findings to field data, compare conventional and improved analysis results, and discuss limitations of the structurally-constrained inversion approach.