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Investigating effects of near-surface resistivity changes on time-lapse ERT inversion

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Basis for reliable groundwater management decisions is always a detailed knowledge of the aquifer. We use time-lapse Electrical Resistivity Tomography (ERT) to deduce hydraulic properties of a hard rock aquifer located in a groundwater protection area (Hastenrather Graben, Germany). As only few groundwater monitoring wells exist there, we monitor the injection of a high resistive contrast water non-invasively from the surface. While doing so, we witnessed strong influences from near surface resistivity changes which covered our expected changes within the aquifer. We report here on one approach to reduce this masking and on computational novelties in dealing with ERT data.

We distinguish between two main sources of disturbance: The first one is related to known surface features like e.g. surface ditches used for drainage with varying water fillings and therefore varying resistivities over time. The second source is due to unknown changes of soil-atmosphere interactions, e.g. water accumulation in slight surface depressions. Additional to these main sources, random noise influences the data.

As measurements are more sensitive to near surface model cells, we inverted the data set with region-dependent regularization factors to allow for small scale changes near the surface and to apply more smoothing in the aquifer where we expect lower sensitivities at the large and slowly moving injection plume. The synthetic results show small scale changes of the first layers which do not influence the inversion result below them as strongly as to inversions with a global regularization factor. The changes in depth are less masked and the simulated injection body is better resolved. Though, predefining the individual regions prior to the inversion procedure requires already a detailed knowledge of the investigated subsurface. Therefore, applying the approach on field data requires careful adjustment to improve the time-lapse inversion results. Preliminary inversion results can potentially be used for this step. This definition of individual inversion zones can not only be performed manually, but also automatically using segmentation methods based on preliminary inversion results. Based on these segments, an updated inversion mesh is generated on which this region dependent regularization factors can be assigned.

We show that this strategy improves the inversion results and allows a better characterization of the aquifer.