Effects of near surface resistivity changes on time lapse ERT inversion

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Time lapse Electrical Resistivity Tomography (ERT) to deduce hydraulic properties of aquifers is widely used in hydrogeology. A major problem while using surface measurement configurations are near surface changes in resistivity over time. Changes in deep aquifer regions we aim to monitor with time lapse ERT might be masked by near surface changes over the monitoring period. We report here on three approaches to overcome such artifacts. First, we applied the different approaches on artificial data and, in a second step, on ERT field data obtained during a fresh water injection test.

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

To deal with the near surface changes, we tried three approaches:
First, we simply excluded the electrodes nearby the ditch to reduce its influence. The results seem to be reliable, but we lose sensitivity in depth of the aquifer. The resolution of the injected plume seems to be decreased. Resistivity changes at other locations are not addressed by this approach. Nevertheless, changes within the aquifer, which we link to our injection, are more distinct, both in the artificial and field data.

Second, we included the shape of the ditch into the inversion mesh and inverted for the values on a very refined mesh. This requires a very long calculation time but the result shows less artifacts at the surface below the ditch. Similar to our first approach, we could replicate the synthetic result on our field data. However, near surface changes at other locations still affect the inversion result of deeper regions.

In a third approach, we inverted the data sets with region dependent regularization factors to allow small scale changes near the surface and to apply more smoothing in the aquifer where we expect 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 strong as before. 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 takes some careful adjusting to improve the time lapse inversion results.

We suggest to simply exclude or downweight heavily disturbed near surface data points during the inversion of time lapse monitoring data. If more knowledge of the subsurface is already available, a region based inversion could improve the results. All known surface features should be included into the inversion mesh or at least be represented by locally refined mesh to avoid artifacts.