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Object-based inversions for electrical resistivity tomography: An approach to better understand water resources

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Summary

We explore a new method of moment-based inversion for surface electrical resistivity tomography (ERT). This method reduces the inversion problem to just solving for several parameters that describe a plume-shaped body in the subsurface. This simplification allows us to overcome some problems related to pixel-based inversions. In practice, this inversion is very sensitive to the choice of background resistivity value and does not converge on the correct answer if there is any small error in the background. However, we can still use this moment-based approach to better understand model sensitivity in a tangible way related to gelogy rather than simply pixel sensitivity.

Introduction

Surface ERT is often used to monitor solute plumes. Inverting the data on a pixel-based grid provides a snapshot of the subsurface conductivity, but even with a large amount of data, the number of model cells outnumbers the amount of independent measurements and sensitivity is variable across the model space. To overcome these problems and converge on a final conductivity image, additional regularization is often imposed, such as smoothness constraints. This regularization can distort the perceived structure of the plume (Singha and Gorelick, 2006). Furthermore, extracting information about a plume from a pixelated image requires an additional level of interpretation, and understanding sensitivity of the model space requires interpreting pixel sensitivity (Furman et al., 2004). In this study, we use moment-based rather than pixel-based parameterization to invert for plume geometry. This eliminates many of the problems from pixel-based inversion.

Theory and/or Method

If we assume a simple Gaussian-shaped plume perturbing the initial background conductivity model, then we can acquire plume location, size, and conductivity value directly from a simple difference inversion (LaBrecque and Yang, 2001). Neither regularization nor pixel image interpretation is required. A similar method was previously used in the linear case (Pidlisecky et al., 2011), but now we are applying it to the nonlinear case. Since we have reduced the dimensionality to only a few model parameters, we are able to explicitly calculate the Jacobian matrix, or the sensitivity of ERT data to model perturbations. If the rows of the Jacobian are independent, each plume moment parameter can be determined uniquely from the data; if they are not independent, parameters can be combined, further reducing dimensionality.

Examples

Our presentation takes a theoretical look at synthetic plumes. However, this inversion method could be applied to several real-world problems with very specific plume geometry, such as conductive solute plume monitoring or tracer tests.

Conclusions

There are many advantages of applying moment-based inversions rather than pixel-based inversions to specific problems where the geometry fits. However, in practice moment-based inversion is not a practical way to solve for subsurface images. Any minor error in the background model causes a large error in the inversion result. There are still several practical uses of moment-based inversion. It allows us to explore model sensitivity related to tangible features rather than simply pixel sensitivity. We can use the Jacobian understand the sensitivity to small changes in the model and the independence of different features of the model. By finding the Jacobian with the most independent rows, we can optimize the survey design for plume monitoring.

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References

Furman, A., T.P.A. Ferré, and A.W. Warrick, 2004. Optimization of ERT surveys for monitoring transient hydrological events using perturbation sensitivity and genetic algorithms. Vadose Zone Journal. 3, 1230–1239.

LaBrecque, D.J., and X. Yang, 2001. Difference Inversion of ERT Data: a Fast Inversion Method for 3-D In Situ Monitoring. Journal of Environmental and Engineering Geophysics. 6(2), 83-89.

Pidlisecky, A., K. Singha, and F.D. Day-Lewis, 2011. A distribution-based parameterization for improved tomographic imaging of solute plumes. Geophysical Journal International. 187, 214-224.

Singha, K, and S.M. Gorelick, 2006. Effects of spatially variable resolution on field-scale estimates of tracer concentration from electrical inversions using Archie’s law. Geophysics. 71(3), G83-G91.