KEYNOTE LECTURE: Advanced ERT inversion strategies with BERT & pyGIMLi

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The quality of both static and dynamic inversion results depends on the density and quality of the data, but also on the availability of additional information on the present state and ongoing processes. BERT (Boundless Electrical Resistivity Tomography) is an open software system for inversion of ERT data and makes use of the flexible numerical pyGIMLi framework providing several abstract modelling, inversion and regularization frames. The talk gives an overview on the possibilities by presenting several cases and outlines the current state of development and future ways.

There is a variety of different transformations and regularization techniques to decrease the ambiguity of the inversion process to geologically plausible models and changes. Besides classical methods, there is the ability of account for properties by geostatistic regularization. Based on the pyGIMLi region technique, one can subdivide the subsurface into units to control their properties individually. This allows, e.g., for adding structural constraints from reflection methods or boreholes. It also enables to use parameter information in boreholes to improve the results in their neighborhood.

BERT is not restricted to point electrodes that are not always an accurate assumption, it also supports arbitrarily shaped facial or line electrodes using the Complete (CEM) and Shunt (SEM) Electrode Models. There is also the possibility of transdimensional inversion, i.e., reducing the dimension of the inversion to 2D, 1D or 1.5D while retaining the full three-dimensionality of the forward problem. The modelling domain can also be formulated in a structural way. Spectral Induced Polarization (SIP) data of different frequencies can be inverted simultaneously using spectral constraints, just like laterally constrained or fully discretized temporal inversions.

Besides the latter, different time-lapse strategies can be followed, from individual over reference model and difference inversion to temporal discretization. Additionally, one can couple ERT with flow and transport models to enable a fully coupled hydrogeophysical inversion for hydraulic conductivity. There are also Python frameworks for different kinds of joint inversion like structurally coupled inversion of data from unrelated methods or petrophysical joint inversion taking into account existing relations between the target parameters.

We exemplify all those strategies and how to use them by illustrative examples from various recent case studies, starting from the classical command line operation to managing classes in Python. Committing to the idea of reproducible science, we are documenting examples in the tutorial and on the documentation websites. Furthermore, we provide all data sets and scripts from published papers in our software repositories on github and gitlab to enable users to benefit and go beyond them, and inviting user to contribute inside of a growing user community.