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Coupled hydrogeophysical modelling and ERT monitoring using pyGIMLi

C. Rücker[(1)*], T. Günther[(2)] and F. Wagner[(3)]

[(1)] Berlin University of Technology, Department of Applied Geophysics, Berlin, Germany
[(2)] Leibniz Institute for Applied Geophysics (LIAG), Hannover, Germany
[(3)] GFZ German Research Centre for Geosciences, Potsdam, Germany
* carsten.ruecker@tu-berlin.de

Among hydrogeophysical methods, Electrical Resistivity Tomography (ERT) is particularly suited for monitoring tasks as it represents a cheap and fast method resolving changes in fluid salinity. For analyzing the data, flexible inversion schemes are required that consider the specific circumstances and subsurface properties. Target is often the understanding of flow and transport processes that can be described by hydrological models. However, up to now ERT and groundwater modelling are two completely disjunct scientific fields which make a joint analysis of data or flexible experimental design impossible.

We present PyGIMLi – A Python Package for Inversion and Modelling in Geophysics, which is an open-source framework that provides tools for modelling and inversion of various geophysical but also hydrological methods. PyGIMLi uses complete Python bindings to the C++ class library GIMLi and includes generalized physical solvers and various tools for pre- and post-processing. The C++-library supplies runtime relevant numerical basics for forward simulation, inversion and discretization management and provides finite-element- and finite-volume-solvers for elliptic, parabolic and hyperbolic problems in 1D, 2D and 3D on arbitrary structured or unstructured meshes. The inversion is generalized and physic independent, solves the minimization problem with a Gauss-Newton algorithm and provides tools for analyzing uncertainty and resolution. More general requirements, such as flexible regularization strategies, time-lapse processing and the petrophysical or structural coupling of various geophysical methods are thereby held independently of the various methods. The BERT software package for resistivity modelling and inversion is a set of specialized applications that is completely based on the pyGIMLi package.

We show a synthetic groundwater modelling example where a saltwater tracer is injected into an aquifer under regional flow boundary conditions. Transport of the dense tracer is simulated using finitevolume-solver for a simplified Navier-Stokes equation and monitored by geoelectrics. We show how the whole simulation process is done within a few lines of scripting code. Furthermore, we demonstrate how the modeled and noisified data are inverted in different ways with the aim of deriving hydrogeophysical parameters from the ERT measurements.