Geophysical Research Abstracts
Vol. 21, EGU2019-11093, 2019
EGU General Assembly 2019

Geostatistical electrical resistivity tomography using Random Mixing

Sebastian Hoerning (1), Lutz Gross (2), Ao Chang (2), and Andras Bardossy (3)

(1) The University of Queensland, EAIT, Centre for Coal Seam Gas, Energi Simulation Industrial Chair Onshore Gas Reservoir Modelling, St Lucia, Australia (s.hoerning@uq.edu.au), (2) The University of Queensland, School of Earth and Environmental Sciences, St Lucia, Australia, (3) University of Stuttgart, Institute for Modelling Hydraulic and Environmental Systems, Department for Hydrology and Geohydrology, Stuttgart, Germany

Electrical resistivity tomography (ERT) is a geophysical method targeting the recovery of the electric conductivity distribution in the subsurface. It is now widely used in a broad range of application areas including environmental engineering, hydrology and mineral exploration.
The key problem of ERT is the inversion step which tries to determine a realistic model, i.e. a spatial distribution of electrical resistivity that gives a reasonable fit to the measured electrical potentials and – if available - satisfies any other prescribed constraints such as well logs. The non-uniqueness of the solution, the non-linear relationships between prediction and assumed conductivity as well as high dimensionality when solving for conductivity distribution are difficulties encountered when solving the ERT inverse problem. Deterministic inversion approaches which are widely used in applications minimize a cost function consisting of the data misfit and a regularization component using some gradient-based iterative technique. The regularization term is added to address the problem of non-uniqueness but does not allow for a proper uncertainty quantification and can result in a solution which is too smooth.
To overcome these problems, we present a geostatistical approach for the ERT inversion problem which supports conditioning through conductivity observations. It is based on Random Mixing which has already successfully been applied in inverse groundwater modelling problems. Random Mixing is a conditional, geostatistical simulation approach which uses spatial copulas as spatial random functions. It iteratively constructs linear combinations of pairs of spatial random fields to simulate a conditional realization of the electrical conductivity. The linear combination is expressed as a one-dimensional optimization problem which aims to minimize the differences between observed and simulated data. Compared to other geostatistical inversion approaches Random Mixing significantly reduces the number of required forward model runs by employing simple Whittaker-Shannon interpolations for all conditioning observations. The approach takes equally spaced points on the unit circle as weights for mixing conditional random fields. Each of these mixtures provides a solution to the forward model at the conditioning locations. For each of the locations the solutions are then interpolated around the circle using Whittaker-Shannon interpolation to provide approximate solutions for additional mixing weights at very low computational cost. The interpolated solutions are used to search for a mixture which maximally reduces the objective function. Once the optimal mixture for two fields has been found, they are combined to form the input for the next iteration of the algorithm. The process is repeated until a threshold in the objective function is met or insufficient changes are produced in successive iterations. As Random Mixing can be used to simulate an ensemble of solutions one can quantify the associated uncertainty. The application to synthetic and a real world test case demonstrates the effectivity of the approach in comparison to deterministic inversion results.