Transdimensional Bayesian inversion of TEM data from the Salar Grande, Chile: A comparative study

J. Roas Domingo[1], B. Blanco Arrué[2], T. Vondenhoff [4], B. Tezkan[1], R. Peng[3] and P. Yogeshwar[1]
[1]University of Cologne, Institute of Geophysics and Meteorology, Germany, yogeshwar@geo.uni-koeln.de
[2]LIAG Institute for Applied Geophysics, Hannover, Germany
[3]School of Geophysics and Geomatics, China University of Geosciences, Wuhan

SUMMARY

The transient electromagnetic method (TEM) is a widely used tool for imaging the distribution of the electrical resistivity in the Earth's subsurface for various geoscientific questions. In its loop source configuration, the technique is primarily used to characterize layered structures, especially delineating zones of high subsurface conductivities. Here, we present 1D TEM inversion results collected over the Salar Grande, one of the most hypersaline enviroments of the Coastal Cordillera in Northern Chile. We used conventional Marquardt-Levenberg (MQ) and Occam inversion techniques, in order to reconstruct the formation of the Salar Grande basin as a sedimentary depo-center, and to provide key information for understanding its evolution to a salar environment. An alluvial fan towards the East of the basin was explored, aiming to study its architecture and to better comprehend the interaction between fan and the Salar Grande sediments. A clear conductive transition to the Salar is visible. In the basin center, the Salar Grande halite body is detected. The conductor below most likely correspond to clay rich paleo-lake sediments. The basement is only visible towards the basin periphery due to a limited exploration depth of roughly 200 m.

Since conventional deterministic inversion techniques do not provide an un-biased uncertainty estimate for the derived subsurface models, we subsequently use probabilistic Bayesian inversion and provide a comparative analysis of both techniques. The goal of Bayesian inference is to approximate the posterior probability density function (PDF) of model parameters for a given data and prior information. The MCMC sampling method is one of the most popular ones, due to its simplicity and robustness. It explores the full model space, in a guided random walk, and produces an ensemble of models to evaluate the posterior probability distribution. To develop improved 1D TEM models with statistically derived uncertainty estimates, the recently developed 1D transdimensional MCMC package *TransdEM* is applied. To ensure that the final models are primarily driven by the data, we set uniform priors with relatively wide bounds. This allows the data to play a more dominant role in sampling the final models, reducing the potential impact of subjective prior choices. Furthermore, the transdimensional property of the algorithm allows the number of unknown model parameters to be determined adaptively by the data. MQ equivalent models also allow an estimate of uncertainty, but they are usually biased towards the best-fitting model. Parameter importances from MQ inversion help us understand the quality and reliability of our models, inferred from observed data. But they do not give us a quantitative analysis of the uncertainty and non-uniqueness of our results.

Our Bayesian results present similar models as the ones from MQ and Occam inversions, but they show a larger uncertainty for the derived models, which ensure more robust and reliable interpretations. The MCMC approach is advantageous, because it independently validates the subsurface structures without using any prior constraints that may cause bias, giving a rigorous quantification of the model ambiguity.

Keywords: transient electromagnetic method, 1D transdimensional Markov Chain Monte Carlo