

Abstract

In the thesis I deal with the development of a stochastic inversion procedure for the magnetotelluric method in 1D/2D isotropic and anisotropic cases, and its application to both synthetic and real data. The magnetotelluric method is a geoelectric inductive technique that utilizes variations of naturally occurring electromagnetic fields as a source of the electromagnetic induction for estimating the Earth's subsurface resistivity to depths of several tens of kilometres. The purpose of the inversion procedure is to estimate a real distribution of the electrical resistivity in the Earth's subsurface from surface measurements. Common inversion procedures in magnetotellurics perform a model optimization by minimizing the misfit between the data and the model response. Stochastic methods are based on the exploration of the model parameter space, and they pick models according to their probability, which makes them effective for the solution of high-dimensional problems which do not show a single pronounced minimum of the target function. The effective ways of mapping the parameter space are sampling algorithms based on Monte Carlo simulations which allow to sort models according to their probability. Results of these methods are obtained in the form of a fully probabilistic description of the parameters, and not in the form of a single model like in the deterministic inversion procedures.

Due to the mentioned advantages of the stochastic methods, I developed a stochastic inversion procedure using a sampling method DREAM, which was specially designed for high-dimensional problems. DREAM can be classified as an adaptive Monte Carlo Markov Chain algorithm. It runs multiple chains in parallel and combines a multi-try sampling with sampling from an archive of past states. I used at first DREAM algorithm in 1D isotropic/anisotropic case and lately for 2D isotropic/anisotropic problem and tested the technique on synthetic models.

I attended a whole series of field experiments during the development of the inversion procedure, where I measured, processed and interpreted new magnetotelluric data, which I could use later for testing the stochastic inversion. The particular targets were tectonic structures in the West Bohemia seismo-active region, the eastern termination of the Bohemian Massif and the vicinity of the Pieniny Klippen Belt in the West Carpathians. The developed algorithm gives satisfactory results in 1D case, as well as for synthetic 2D isotropic problems. The algorithm achieves worse results in 2D real isotropic examples only in case of large number of parameters (> 500). In case of 2D anisotropic problems, both synthetic and practical, the algorithm reaches better results than the classical non-probabilistic procedures. The developed stochastic algorithm gives overall satisfactory results and, despite its high computational costs, it benefits from offering full probability maps of the solution space, and thus estimates of the uncertainties of the solutions.