PARAMETERIZATION AND UNCERTAINTY ESTIMATION IN LINEARIZED AND NONLINEAR BAYESIAN MAGNETOTELLURIC INVERSION

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This paper employs Bayesian inference theory to study parameterization, parameter uncertainty estimation, and nonlinearity for the one-dimensional magentotelluric (MT) inverse problem. In the Bayesian formulation, the complex impedance data and the model parameters (conductivities and/or layer thicknesses) are all considered as random variables. The multi-dimensional posterior probability density (PPD), combining data and prior information, is interpreted in terms of parameter estimates, uncertainties, and interrelationships which require optimizing and integrating the PPD. In the nonlinear formulation, optimization is carried out using an adaptive-hybrid algorithm that combines very-fast simulated annealing and the downhill simplex method. Integration applies Markov-chain Monte Carlo sampling, rotated to a principal-component parameter space for efficient sampling of correlated parameters. Since appropriate model parameterizations are generally not known a priori, both over- and under-parameterized approaches are considered. For over-parameterization, prior information is included which favours simple structure in a manner similar to regularized (Occam's) inversion. The data error variance and tradeoff parameter regulating data and prior information are included as nuisance parameters in the PPD sampling. For under-parameterization, the maximum a posteriori (MAP) solution is determined for a sequence of problems with an increasing number of layers, and the appropriate parameterization is chosen using the Bayesian information criterion for model selection. The nonlinear inversion results in terms of one- and two-dimensionl marginal probability distributions and marginal probability profiles are compared to linearized inversion results for both the under- and over-parameterized approaches. Although generally similar, some significant differences in recovered parameter uncertainties between the nonlinear and (approximate) linearized approaches are indicated. In addition, treating the data variance and/or tradeoff parameter as unknown results in only a small increase in model uncertainties (compared to *a priori* known values), indicating that the data contain sufficient information to constrain these parameters as well as the conductivity model.

Bayesian inversion, nonlinear inversion, parameter uncertainty estimation

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