Uncertainty quantification in geological modelling by Hessian-informed MCMC

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Uncertainty quantification is an important aspect of geological modelling and model interpretation. Recent developments in geological modelling allow us to view the inversion as a problem in Bayesian inference, incorporating the uncertainties in the observations, the forward models and the prior knowledge from geologists. The sampling method Markov chain Monte Carlo (MCMC) is then often applied to solve this inference problem. However, this stochastic modelling approach is limited as the number of parameters increases to higher dimensions. To ensure an efficient sampling in a high dimensional problem, we take advantage of recent advances using Hessian-based MCMC methods in this work. The Hessian of the negative log posterior with respect to the input parameters is evaluated at the Maximum a Posteriori (MAP) point. A Laplace approximation of the posterior at the MAP is then given by the inverse of the local Hessian. This sampling approach provides a potentially less computationally expensive and more efficient way for high dimensional geological inverse modelling, especially in cases where parameters are highly correlated, a situation that commonly arises in geological modelling.