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Bayesian Inversion for quasi-linear models in geodesy

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We consider the Bayesian inversion of quasi-linear models by means of Monte-Carlo methods. Quasi-linear models are a class of non-linear models, which can be cast in matrix-vector form but whose design matrix depends on a subset of the unknown parameters. A large class of nonlinear geodetic problems can be formulated as quasi-linear models. As there exist no general analytical solutions for the quasi-linear model, Monte Carlo optimization techniques in the context of a Bayesian inversion approach are investigated here. In order to accelerate the Monte Carlo method we utilize the analytical solution of the linear model under the condition that the unknown parameters in the design matrix are considered as constant. Thereby the sampling dimension in the Monte Carlo approach can be reduced. The estimators for expectation and covariance of the parameters that we derive turn out as weighted means of the individual sample least-squares solutions. We develop an efficient set of algorithms for the solution of quasi-linear models using Monte Carlo techniques and demonstrate the efficiency of the method in a numerical example from satellite geodesy and gravity field recovery. Two groups of unknown parameters are relevant in this example: the spherical harmonic coefficients of a gravity field model, and the state vectors of the satellite(s) which affect the observation model through the design matrix.