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Uncertainty Quantification and Inverse Problems

The Bayesian formulation of inverse problems, particularly parameter identification problems for PDEs, has received increased attention from the Uncertainty Quantification community. Besides offering a natural framework for expressing mathematically the degree of uncertainty to which a model parameter to be estimated is known both before and after observations have been made as well as incorporating stochastic observational noise models, the Bayesian formulation is well-posed under natural assumptions and has extensions to infinite-dimesional parameter spaces. We present efficient numerical methods for sampling from the posterior distribution, a probability measure on a typically infinite-dimensional space, which represents the solution of a Bayesian inverse problem. These methods are based on Markov chain Monte Carlo sampling using a refinement of the recent preconditioned Crank-Nicolson proposal scheme. To achieve efficiency, is is crucial that the sampling algorithms be robust with respect to the discretization of the parameter space as well as the noise variance. We illustrate the performance of the method for an application in groundwater flow.