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BIG DATA MEETS BIG MODELS: LARGE-SCALE BAYESIAN INFERENCE, WITH APPLICATION TO INVERSE MODELING OF ANTARCTIC ICE SHEET DYNAMICS

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Predictive models of complex geoscience systems often contain numerous uncertain parameters. Rapidly expanding volumes of observational data present opportunities to reduce these uncertainties via solution of inverse problems. Bayesian inference provides a systematic framework for inferring model parameters with associated uncertainties from (possibly noisy) data and any prior information. However, solution of the Bayesian inverse problem via conventional Markov chain Monte Carlo methods remains prohibitive for expensive models and high-dimensional parameters, as result from discretization of infinite dimensional problems with uncertain fields. Despite the large size of observational datasets, typically they can provide only sparse information on model parameters. Based on this property we design MCMC methods that adapt to the structure of the posterior probability and exploit an effectively-reduced parameter dimension, thereby making Bayesian inference tractable for some large-scale, high-dimensional inverse problems. We apply the methodology to an inverse problem for Antarctic ice sheet flow: given a non-Newtonian flow model of the ice sheet and free surface velocity observations, we seek to infer the sliding coefficient field at the base of the ice. We demonstrate scalability with respect to state dimension, parameter dimension, data dimension, and number of processor cores.

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