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Inferring ground surface temperature histories from underground data using Reversible Jump MCMC methodology

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One issue in inferring ground surface temperature (GST) histories from borehole data is the resolution of the inferred GST reconstruction and the level of uncertainty that accompanies a given inverse ‘solution’. Applications of Bayesian inference have gained much attention in the statistical community and are beginning to find applications in many areas of geophysics. In this work, we apply a Bayesian Markov chain Monte Carlo method in order to infer the uncertainty in the GST history derived from typical borehole temperature profiles.

In a fully Bayesian formulation the surface temperatures and all other model parameters are taken as unknown quantities described through probability density functions rather than single ’true’ values. Direct sampling of the multi-dimensional posterior distribution, which describes all model parameters conditioned on the data and prior information, is achieved by using a Markov chain Monte Carlo algorithm (MCMC). In this work a Reversible Jump MCMC algorithm has been used which takes into account how complex the GST model is by allowing ’jumps’ between models of differing dimensionality.

The Reversible Jump MCMC method has been tested on synthetic data sets and also with real data from the International Heat Flow Commission database. The resultant posterior probability density functions depict the resolution over time of the GST history. The probability densities can be quantified in terms of sample means, 95% Bayesian credible intervals and the probability distribution of the model size. These can be used to identify poor resolution in GST signals and the maximum length of the reconstruction that is adequately resolved. The probability distributions can aid com-

parisons with other palaeo-climate studies, because the true uncertainty of the GST reconstruction is accounted for.