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Inferring spatial climatic trends from borehole data using a Bayesian partition model

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Estimates of the spatial component of past surface temperature change are now routinely inferred from large collections of suitably selected borehole temperature depth profiles. Usually, individual reconstructions are derived at each site and the resultant temperature histories are averaged across a spatial grid. However, because of this averaging, the parameters used in each inversion must be kept the same and so may not necessarily be best suited at each site. Additionally, when the boreholes are unevenly located, the uncertainty across the spatial grid can begin to vary.

In this work we present a different approach to this problem which utilises a Bayesian partition model. This progresses by dividing the spatial domain into a number of partitions defined by Voronoi tessellations. Each partition is then assumed to relate to a distinct surface temperature history. The posterior probability distribution of the partition locations and the associated temperature histories is then conditional on the temperature-depth profiles and their locations and prior information. The posterior distribution is sampled using a Reversible Jump Markov chain Monte Carlo (RJ-MCMC) algorithm which allows for a varying number of partitions. A secondary RJ-MCMC algorithm is run in each partition in order to find a temperature history which is suitable to the enclosed boreholes. Bayes' Law automatically penalises unwarranted model complexity through the number of terms in the prior distribution and so the simplest model setup which can satisfy the data is favoured. This feature is demonstrated with realistic synthetic data whilst the methodology has been applied to real dataset of 23 borehole profiles from the United Kingdom.