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A Bayesian Perspective on Targeting Basement Conductors Using Airborne Electromagnetic Data

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The delineation of potentially economic basement conductors, such as a subvertical massive sulphide body, is often the prime motivation for the acquisition of airborne and ground electromagnetic data in greenfield exploration. The electromagnetic response of such basement conductors can be modelled efficiently using a thin plate approximation, which is central to the computational feasibility of Bayesian approaches. Here we introduce a bootstrapping technique as a computationally efficient alternative to the commonly employed Markov chain Monte Carlo technique. Our Bayesian parametric bootstrap infers a thin plate layered earth hybrid model and associated uncertainties from multiple "bootstrapped" electromagnetic data sets. It treats prior information on the model and its spatial correlation as implied observations, and then applies the classical parametric bootstrap. Studies on synthetic examples demonstrate that a Bayesian parametric bootstrap approach provides an adequate exploration of model space for non-pathological situations, while requiring many fewer forward problem solves than a comparable Markov chain Monte Carlo algorithm.

A crucial early decision in an exploration program for basement conductors is whether an anomaly in the data is caused by a distinct target conductor, or simply due to background conductivity variations. From a Bayesian perspective, this is a model selection problem, where a target in the basement leads to an increase in the number of model parameters that should be justified by a significantly increased fit to the data. Here we quantify this trade-off between model complexity and fit to the data using the Bayes factor as a model selection criterion. It allows us to objectively quantify support in the data for discrete basement targets, and objectively rank anomalies in the data according to their likelihood of being caused by a basement conductor, which we model as a thin inductive plate.

Once a discrete conductor has been identified, further exploration activities are then ideally based on understanding the robustness of the model inferred from the data. Using the Walford Creek prospect in North West Queensland Australia as an example, we demonstrate how our approach can recover a plate-like target from multiple GEOTEM flight lines in the vicinity of a fault associated with a conductivity contrast. Recovered uncertainties reveal both the expected trade-off between model parameters, such as plate size and plate conductance, but also compelling evidence of sufficient exploration of model space. Our results demonstrate that the Bayesian parametric bootstrap is an attractive compromise between efficiency and exhaustive stochastic search in uncertainty quantification for a thin plate layered earth hybrid model. We conclude by discussing how the efficiency of the approach is central to a pragmatic follow-up survey optimisation.