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Bayesian hierarchical approach combined with geostatistics for temperature modeling using a well-logging dataset

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Subsurface temperature modelling plays an important role in both exploration of renewable geothermal resources and sophisticated understanding of paleo-temperatures. This study is aimed to develop a physical-statistical analysis method which integrates Bayesian hierarchical modelling and geostatistics for temperature modelling in the upper crust. Hokkaido, northern Japan, is selected for a case study and temperature profiles from 433 boreholes of a database compiled by the Japan Atomic Energy Agency (JAEA) are used in this study.

The Bayesian hierarchical approach relies on modelling heat conduction in solids through heat equation with surface boundary conditions assumed as random processes. The surface temperatures over time act as boundary conditions for temporal changes in subsurface evolution. Then the data with respect to the subsurface temperatures can be inverted to estimate the boundary conditions for different depths. Surface temperature history processes were modelled for prior distribution. Ground surface temperature histories and temperature at different depths with uncertainty were produced. Finally, kriging based geostatistics estimation and simulation were used to map the temperature change with time.