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Calibrating a geothermal reservoir model using microgravity data

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Microgravity measurements can be affected by changes in mass of a geothermal reservoir, and can therefore be sensitive to changes in fluid influx, outflux and phase state. In New Zealand, repeat high-precision microgravity surveys have been performed at a number of producing geothermal fields over the last 20 years. However this data is not routinely included in reservoir models used to study the fields. The goal of this project is to develop a methodology that allows a shallow reservoir model to be calibrated against microgravity data, and to apply it to a high-temperature geothermal field. The results are used to refine the initial reservoir model and investigate which parameters influence the changes in microgravity data.

A shallow reservoir model down to 500 m is developed from a full-field model that was calibrated with well enthalpy and pressure data. Gravity changes at measurement locations are calculated using density values produced from the shallow reservoir model. The PEST software is used to run this calculation multiple times, comparing the calculated gravity with measured data at each iteration. The PEST calculations invert for a variety of parameters including porosity, permeability, fluid flux rates at the base of the model, fracture volume and spacing, and the extent of fluid flow at depth.

The starting numerical model captures the first-order features of the microgravity data. However, by changing the fluid flux at 500 m depth and the bulk rock permeability and porosity, the average misfit between modelled and measured microgravity data can be reduced by more than a third. Although the fit between model results and measured data can be significantly improved by changing parameters like porosity and permeability, it still does not replicate all the features of the data such as a decrease in gravity in the periphery of the geothermal field. Therefore either the structure of the reservoir model needs some refinement, or the gravity data may be influenced by deeper changes within the geothermal system.