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Basin-scale geothermal model calibration: experience from the Perth Basin, Australia

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The calibration of large-scale geothermal models for entire sedimentary basins is challenging as direct measurements of rock properties and subsurface temperatures are commonly scarce and the basal boundary conditions poorly constrained. Instead of the often applied "trial-and-error" manual model calibration, we examine here if we can gain additional insight into parameter sensitivities and model uncertainty with a model analysis and calibration study.

Our geothermal model is based on a high-resolution full 3-D geological model, covering an area of more than 100,000 square kilometers and extending to a depth of 55 kilometers. The model contains all major faults (>80) and geological units (13) for the entire basin. This geological model is discretised into a rectilinear mesh with a lateral resolution of 500 x 500 m, and a variable resolution at depth. The highest resolution of 25 m is applied to a depth range of 1000-3000 m where most temperature measurements are available. The entire discretised model consists of approximately 50 million cells. The top thermal boundary condition is derived from surface temperature measurements on land and ocean floor. The base of the model extents below the Moho, and we apply the heat flux over the Moho as a basal heat flux boundary condition. Rock properties (thermal conductivity, porosity, and heat production) have been compiled from several existing data sets.

The conductive geothermal forward simulation is performed with SHEMAT, and we then use the stand-alone capabilities of iTOUGH2 for sensitivity analysis and model calibration. Simulated temperatures are compared to 130 quality weighted bottom hole temperature measurements. The sensitivity analysis provided a clear insight into the most sensitive parameters and parameter correlations. This proved to be of value as strong correlations, for example between basal heat flux and heat production in deep geological units, can significantly influence the model calibration procedure. The calibration resulted in a better determination of subsurface temperatures, and, in addition, provided an insight into model quality. Furthermore, a detailed analysis of the measurements used for calibration highlighted potential outliers, and limitations with the model assumptions.

Extending the previously existing large-scale geothermal simulation with iTOUGH2 provided us with a valuable insight into the sensitive parameters and data in the model, which would clearly not be possible with a simple trial-and-error calibration method. Using the gained knowledge, future work will include more detailed studies on the influence of advection and convection.