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Geothermal reservoir modelling by using dynamic unstructured meshes for improved heat recovery in highly heterogeneous reservoirs

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Numerical modelling of fluid flow and heat transport in geothermal reservoirs can be very challenging. One reason is the broad range of length-scales that control the flow behaviour, spanning several orders of magnitude from fractures (millimetre-scale) and wells (metre-scale) to facies architecture and faults (kilometre-scale). The usual approach for modelling geothermal reservoirs is to discretise the equations using the finite-volume method and variants thereof to ensure mass conservation, subdividing space onto a fixed, structured mesh. However, using a fixed mesh resolution across the entire model domain can be very computationally expensive, and prohibitive if the model must resolve many length-scales.

Here we report an efficient method to apply dynamic mesh optimisation (DMO) to model geothermal reservoirs. DMO is widely used in other areas of computational fluid dynamics because it offers significant advantages in providing higher resolution, multi-scale solutions at much lower computational cost. However, application of DMO to geothermal reservoir modelling has so far been very limited.

The method reported here uses a surface-based representation of all geological heterogeneity that should be captured in the model. The numerous surfaces in the model represent geologic features such as faults, fractures, and boundaries between rock types with different material properties. The surfaces bound rock volumes, termed geologic domains, within which material properties are constant. When simulating flow and heat transport, the mesh dynamically adapts to optimize the representation of key solutions metrics of interest such as temperature, pressure, flow velocity or fluid saturation, but the surface architecture is preserved. The advantage of this approach is that up-, cross- or down-scaling of material properties during DMO is not required, as the properties are uniform within each geologic domain.

We demonstrate the method using a number of example problems, including complex wells. Another advantage of our approach is that well trajectories are accurately represented as the mesh conforms to the wells. The well trajectory is also preserved during DMO. We show that more accurate results are obtained at lower computational cost as compared to conventional, fixed mesh approaches.