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Dynamic mesh optimisation for geothermal reservoir modelling

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Numerical modelling of fluid flow and heat transport in geothermal reservoirs can be very challenging due to the need of modelling several length-scales simultaneously that control the flow behaviour. The lenght-scales to consider typically go 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 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 simultaneously. Moreover, large domains may be necessary as well to avoid boundary effects and to include the whole convective system hosting a particular reservoir.

In other areas of computational fluid dynamics, high fidelity solutions have been obtained at lower computational cost by use of dynamic mesh optimisation (DMO), in which the resolution and geometry of the mesh varies during a simulation to minimize an error metric for one or more solution fields of interest such as pressure or velocity. DMO varies the mesh resolution such that higher resolution is used in parts of the domain where the solution is complex, and lower resolution is used elsewhere.

Here we report an efficient method to apply dynamic adaptive mesh optimisation (DMO) to model geothermal reservoirs. The method reported here uses a surface-based representation of all geological heterogeneity that should be captured in the model. In surface-based geologic modelling (SBGM), all geological heterogeneities of interest are represented by surfaces: these surfaces may capture faults, fractures, stratigraphic surfaces, etc. The surfaces define rock volumes which we term 'geologic domains''. These domains have constant petrophysical properties, or simple, mathematically defined trends such as upwards or downwards increases in permeability. When simulating, the mesh dynamically adapts to optimise the representation of key solutions metrics of interest, but the surface architecture is preserved.

We demonstrate the method using a number of example problems including wells and high permeable fractured media. These heterogeneous test cases represent common reservoir scenarios that can be difficult to represent in conventional geothermal reservoir modelling workflows. We focus here on thermal-hydrological (TH) processes in the low enthalpy geothermal systems that are used to source and store heat in many different locations around the world. Another advantage of our approach is that well trajectories are accurately represented as the mesh conforms to the well-path. We show that more accurate results are obtained, while modelling simultaneously several length-scales, at lower computational cost as compared to conventional fixed mesh approaches.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

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