Geophysical Research Abstracts
Vol. 19, EGU2017-13919, 2017
EGU General Assembly 2017

Integration of complex reservoir grids for hydromechanical coupling

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Geomechanics became an integral part in the assessment of geological subsurface utilization during the last decade. However, complex grids as applied in state-of-the-art reservoir simulation, including local grid refinements, pinch-out elements resulting from geological discontinuities and reservoirs of low thickness, hinder a straight-forward integration of these grids into geomechanical simulations. Hence, the geomechanical modelling community tends to simplify their grid discretization schemes to meet the grid geometry criteria required by geomechanical simulators or to apply complex interpolation methods between reservoir simulation and geomechanical grids. Both approaches are known to result in significant deviations compared to coupled simulations conducted on the very same grid. Hereby, the application of specific interpolation methods further demands for careful result verification between single parameter transfers between both simulation grids, e.g., including the development of model-specific verification procedures. Consequently, utilization of identical grids in both simulators should be preferred over both workarounds.

Resolving this pressing issue, we implemented a fast algorithm using FLAC3D [1] intrinsics (C++), allowing for an efficient and seamless integration of Schlumberger ECLIPSE grids [2], generated using, e.g., the Petrel software package [3], including pinch-out elements and local grid refinements (LGRs). This algorithm comprises four major steps: (1) read the ECLIPSE global grid (hexahedron and pinch-out elements) and generate a compressed corner point grid with unique element nodes; (2) read any LGRs present in the model and transfer these to the geomechanical grid using the previously retrieved global grid information; (3) verify if all (including pinch-outs) element geometries meet the geomechanical grid geometry criteria and revise these elements as required; (4) parametrize the global grid and LGR elements and maintain a data structure for parameter exchange between reservoir and geomechanical simulators.

Using the algorithm enables modellers to transfer multi-million element ECLIPSE grids to, e.g., FLAC3D for coupled hydromechanical simulations within a few minutes instead of employing time-consuming grid simplification or parameter interpolation, while maintaining an efficient data structure for parameter exchange during the specific coupling steps.

[1] Itasca. FLAC3D Software Version 5.01, Advanced Three Dimensional Continuum Modelling

for Geotechnical Analysis of Rock, Soil and Structural Support. User's Manual. 2015.

[2] Schlumberger. ECLIPSE Reservoir Engineering Software, Version 2015.1; 2015.

[3] Schlumberger. Petrel Seismic-to-Evaluation Software, Version 2015; 2015.