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Impact of artificial topological changes on flow and transport through fractured media due to mesh resolution

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We performed a set of numerical simulations to characterize the influence of mesh refinement and upscaling on flow and transport properties in fractured porous media. We generated a set of generic three-dimensional discrete fracture networks at various densities, where the radii of the fractures were sampled from a truncated power-law distribution, whose parameters were loosely based on field site characterizations. We also considered five network densities, defined using a dimensionless version of density based on percolation theory. Once the networks were generated, we upscaled them into a single continuum model using the upscaled discrete fracture matrix model presented by Sweeney, Gable, Karra, Stauffer, Pawar, and Hyman (2020). We considered steady, isothermal pressure-driven flow through each domain and simulated passive/conservative, decaying, and adsorbing tracers using a pulse injection into the domain. We calculated the effective permeability and solute breakthrough curves for each simulation as quantities of interest to compare between network realizations. We found that selecting a mesh resolution such that the global topology of the upscaled mesh matches the fracture network is essential. If the upscaled mesh has a connected pathway of fracture (higher permeability) cells, but the fracture network does not, then the estimates for effective permeability and solute breakthrough will be incorrect. Local false connections between fractures due to a coarse mesh result in more solute dispersion in the transport behavior, but to a smaller degree than if there is a mismatch in global connectivity. False connections cannot be eliminated entirely, but they can be managed by choosing the appropriate mesh resolution and refinement for a given network. Adopting octree meshing to obtain sufficient levels of refinement leads to fewer computational cells (up to a 90% reduction in overall cell count) when compared to using a uniform resolution grid and can result in a more accurate continuum representation of the true fracture network.

Participation

In-Person

References

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