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A reduced-order model to assist real-time predictions of gas transport in unsaturated fractured media

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Gas transport in unsaturated fractured media plays an important role in applications such as shallow CO2 leakage from carbon sequestration sites, methane leaks from oil and gas operations, and remediation of volatile contaminant plumes. Driven primarily by barometric pumping, the time scale of relevant gas transport can vary from months or years to the order of days depending on a variety of hydrogeologic parameters, including: rock type, fracture aperture, matrix permeability, porosity, and saturation. It is very difficult to use computationally expensive numerical simulations to make real-time predictions of gas transport when parameter uncertainty is high and/or there is potential for rapid transport. We propose a reduced-order model (ROM) of gas transport in fractured media as a means of reducing computational complexity and allowing quicker approximations of migration time scales to assist real-time decision-making as it concerns gas transport. We build our ROM using relationships from a parameter sensitivity study of a two-dimensional single-fracture numerical flow and transport model simulated using PFLOTRAN and FEHM codes. Our modeled flow results are benchmarked where appropriate by a corresponding analytical solution for the subsurface pressure response from a harmonically varying barometric pressure fluctuation at the surface. This ROM can aid in bracketing real-time estimates of gas transport and has the potential to be generalized to more complex three-dimensional and discrete fracture networks.

References

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