Contribution ID: **386** Type: **Oral Presentation**

A Particle-Tracking Scheme with Adaptive Diffusion for Multiphase Flows in Fractured Porous Media

Thursday, 2 June 2022 14:45 (15 minutes)

Advection dominated transport processes in sub-surface formations are characterized by discontinuities in the fields of transported quantities, e.g., concentration in the context of solute transport, phase-saturation in multiphase flows. Realistic predictions are challenging for Eulerian schemes because they suffer from numerical dispersion. This, however, does not limit Lagrangian particle-tracking methods, which makes them particularly relevant for advection dominated processes [Michalak and Kitanidis, (2000)].

We are interested in transport in fractured porous media with a permeable matrix, and adopt an Embedded Discrete Fracture Model where fractures are treated as lower dimensional manifolds [Deb and Jenny, (2017)]. However, the fracture-matrix interface is not resolved. In Monga et al. (2020), we presented a conservative stochastic particle-tracking scheme for advective solute transport in single-phase flow. This scheme uses a two-state Markov chain with transition probabilities for inter-continuum particle transfer. The probabilities are pathline-specific and scale with the particle's modeled travel time through the grid cell.

The focus of the present work is to improve the efficiency of the mentioned stochastic particle scheme and extend it to model saturation evolution in two-phase immiscible flows. Saturation evolution is simulated by the motion of two particle ensembles, i.e., one for each phase [Tyagi et. al (2008)].

For flows with high Péclet numbers and without capillary pressure differences, saturation transport is hyperbolic in nature. With finite particle ensemble sizes, capturing saturation discontinuities becomes challenging due to inaccurate cell-saturation estimates and related instabilities at saturation fronts. We aim to tackle this by including an adaptive diffusivity to the system, which selectively acts in the vicinity of the saturation front and remains inactive away from the front. To this end, a Smagorinsky-type [Smagorinsky (1963); Lilly (1966)] diffusion coefficient is proposed, which scales with the magnitude of the saturation gradient. Our goal is to keep the expression quantifying the coefficient's magnitude generic, without the necessary adjustments for different flow scenarios.

The proposed particle scheme is potentially extendable to multi-species settings and enables the straightforward formulation of Lagrangian models for locally unresolved sub-grid processes such as phase dissolution or trapping.

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References

1. Michalak, A. M., & Kitanidis, P. K. (2000). Macroscopic behavior and random-walk particle tracking of kinetically sorbing solutes. Water Resources Research, 36(8), 2133-2146.
2. Deb, R., & Jenny, P. (2017). Finite volume–based modeling of flow-induced shear failure along fracture manifolds. International Journal for Numerical and Analytical Methods in Geomechanics, 41(18), 1922-1942.
3. Monga, R., Deb, R., Meyer, D. W., & Jenny, P. (2020, September). Particle Transport Scheme for Embedded Discrete Fracture Models. In ECMOR XVII (Vol. 2020, No. 1, pp. 1-15). European Association of Geoscientists & Engineers.
4. Tyagi, M., Jenny, P., Lunati, I., & Tchelepi, H. A. (2008). A Lagrangian, stochastic modeling framework for multi-phase flow in porous media. Journal of Computational Physics, 227(13), 6696-6714.
5. Smagorinsky, J. (1963). General circulation experiments with the primitive equations: I. The basic experiment. Monthly Weather Review, 91(3), 99-164.
6. Lilly, D. K. (1966). On the application of the eddy viscosity concept in the inertial sub-range of turbulence. NCAR Manuscript, 123.

Time Block Preference

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

Participation

In person

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