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A Compact One-Domain Approach for Momentum Transport at Porous Media Boundaries

Abstract. Momentum transport at porous media boundaries is usually modeled with a two-domain approach, which requires the use of coupling boundary conditions. While this approach has received significant attention over the past fifty years [1], a debate about the boundary conditions pertinence still lingering [2], a one-domain approach can also be considered. In this alternative, a single equation is used within the homogeneous portion of a porous medium and near the boundaries. Classically, a penalization procedure is used in which a Darcy-like term is added to the Navier-Stokes equations. Such equation is not of practical value due to its complexity and the difficulty to predict the spatial variations of the permeability. In this work, both limitations are surpassed by deriving a macroscale model that has a Darcy-like form and includes a closure scheme to predict the spatial changes of the permeability. The model is derived using a simplified volume-averaging method considering steady and single-phase flow under slip and inertial conditions. The model is validated by comparisons with pore-scale simulations [3] and also with experimental data showing excellent agreement [4].

References

[1] Nield, D.A. (2009). Transport in Porous Media, 78, 537-540. [2] Eggenweiler E., Rybak I. (2020). Journal of Fluid Mechanics, 892, A10. [3] Valdés-Parada F.J., Lasseux D. (2021). Physics of Fluids, 33, 073612. [4] Valdés-Parada F.J., Lasseux D. (2021). Physics of Fluids, 33, 022106.

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