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Upscaling the Navier-Stokes Equation for Turbulent Flows in Porous Media Using a Volume Averaging Method[1] BRIAN WOOD, XIAOLIANG HE, SOURABH APTE, Oregon State University — Turbulent flows through porous media are encountered in a number of natural and engineered systems. Many attempts to close the Navier-Stokes equation for such type of flow have been made, for example using RANS models and double averaging. On the other hand, Whitaker (1996) applied volume averaging theorem to close the macroscopic N-S equation for low Re flow. In this work, the volume averaging theory is extended into the turbulent flow regime to posit a relationship between the macroscale velocities and the spatial velocity statistics in terms of the spatial averaged velocity only. Rather than developing a Reynolds stress model, we propose a simple algebraic closure, consistent with generalized effective viscosity models (Pope 1975), to represent the spatial fluctuating velocity and pressure respectively. The coefficients (one 1st order, two 2nd order and one 3rd order tensor) of the linear functions depend on averaged velocity and gradient. With the data set from DNS, performed with inertial and turbulent flows (pore Re of 300, 500 and 1000) through a periodic face centered cubic (FCC) unit cell, all the unknown coefficients can be computed and the closure is complete. The macroscopic quantity calculated from the averaging is then compared with DNS data to verify the upscaling.

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