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ON THE RELATIONSHIP BETWEEN MULTIPLE POROSITY MODELS AND CONTINUOUS TIME RANDOM WALK

Jan M. Nordbotten and Leonid Vasilyev
Department of Mathematics
University of Bergen, PB 7800, 5020 Bergen, Norway
e-mail: jan.nordbotten@math.uib.no
e-mail: leonid.vasilyev@math.uib.no

Summary. Transport models for porous media have long been the topic of heated debate. While ordinary Fickian transport may be applicable at some sites (such as the Cape Cod experiment), experiments frequently show that even tracer transport cannot be modeled as Fickian.

The most common approach to non-Fickian transport in porous media remains the dual porosity model, which makes a heuristic accounting for the interaction between fast and slow flow paths. The dual porosity model remains a continuum scale model, which typically does not explicitly account for fine scale structure. While multiple porosity models are simple to implement and use, they have the significant drawback that the parameters of the model are hard to derive from first principles.

In contrast, the Continuum Time Random Walk models (CTRW) are derived from the statistics of the fine scale flow paths. While conceptually more complex than the dual porosity model, the CTRW model gives a much greater flexibility in modeling, since a more detailed description of the pore scale is available to the model. We thus consider the CTRW a meso-scale model. Remarkably, it has been shown that the full statistical description of the fine scale flow paths may frequently not be needed, as the core properties of flow are only dependent on the tailing behavior of the distribution. In such a setting, CTRW may also be considered a continuum scale model.

In this work, we seek to shed more light on the relationship between the seemingly disparate worlds of CTWR and multiple porosity models. Through analysis, we show that these two models can be seen as discretizations of the same underlying model. Thus, in the continuous limit of CTRW (close spacing of spatial locations, or smooth concentration fields), it coincides with an multiple (infinite) porosity model. We arrive at explicit relationships between the parameters of multiple porosity models and CTRW. These relationships are especially valuable in establishing the interaction coefficients in multiple porosity models.