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Simulation of density-driven flow in heterogenous and fractured porous media

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The study of fractured porous media is an important and challenging problem in hydrogeology. One of the difficulties is that mathematical models have to account for heterogeneity introduced by fractures in hydrogeological media. Heterogeneity may strongly influence the physical processes taking place in these media. Moreover, the thickness of the fractures, which is usually negligible in comparison with the size of the whole domain, and the complicated geometry of fracture networks reduce essentially the efficiency of numerical methods. In order to overcome these difficulties, fractures are sometimes considered as objects of reduced dimensionality (surfaces in three dimensions), and the field equations are averaged along the fracture width. Fractures are assumed to be thin regions of space filled with a porous material whose properties differ from those of the porous medium enclosing them. The interfaces separating the fractures from the embedding medium are assumed to be ideal. We consider two approaches:
(i) the fractures have the same dimension, d, as the embedding medium i.e. they are d-dimensional;
(ii) the fractures are considered as (d-1)-dimensional manifolds, and the equations of density-driven flow are found by averaging the d-dimensional laws over the fracture width.
We show that the second approach is a valid alternative to the first one. For this purpose, we perform numerical experiments using a finite-volume discretization for both approaches. The results obtained by the two methods are in good agreement with each other.
We derive a criterion for the validity of the simplified representation. The criterion characterises the transition of a mainly parallel flow to a rotational flow, which can not be reasonably approximated using a d-1 dimensional representation. We further present a numerical algorithm using adaptive dimensional representation.

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