Adaptive Fup Finite Volume Method for groundwater flow modelling in highly heterogeneous porous media

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ABSTRACT

Contaminant and tracer transport, groundwater age or remediation analysis as well as many other important transport applications require demanding solving of the Darcy flow in heterogeneous porous media [1]. Groundwater flow simulations, especially in large, highly heterogeneous and anisotropic aquifers, require multi-resolution approach due to resolving many heterogeneity scales, extensive computational resources and accurate velocity field. Despite development of modern numerical and stochastic methods with many desirable properties, the majority of groundwater community has used common numerical methods based on the finite element and finite volume approaches through the Monte Carlo method. These common methods assume discontinuous conductivity field (or piecewise cell/element continuous) and mesh based limitations causing velocity discontinuities and/or numerical errors along the cell or element interfaces introducing additional numerical dispersion. Reliable transport simulations, which support velocity dependent dispersion tensor, require very accurate velocity field which enables mass balance property, continuity of velocities and its derivatives and resolving of all heterogeneity scales. Usually, at least some of these properties are violated by all existing methods (not only common methods), especially truly multiresolution conceptualization and continuity of velocities derivatives. In this paper, we present novel **A**daptive **F**up **F**inite **V**olume **M**ethod (AFFVM), based on *Fup* basis functions and concept of the finite control volumes [2,3]. New methodology satisfies mass balance exactly on the finite volumes and presents conductivity and head as continuous functions independently to each other in meshless and multiresolution way using only linear combination of Fup basis functions finding all spatial scales for both variables. Due to the finiteness and approximation properties of these basis functions, velocity field (using the Darcy law) and its derivatives are continuous and obtained by prescribed accuracy satisfying all mentioned requirements. Methodology is presented and verified using the 2-D and 3-D numerical and stochastic benchmark simulations.

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