**A Multiscale Restricted Smoothed Basis Method Coupled with High Resolution Correction Procedure via Reconstruction Method, Using Different Solution Smoothers for the Simulation of Oil-Water Flows in Petroleum Reservoir**

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The modeling and simulation of multiphase flows in heterogeneous and anisotropic media constitute a major mathematical and numerical challenge. However, it provides essential tools for reservoir engineering, as it allows the prediction of the performance of the hydrocarbon reservoir in various operational strategies. The use of very high-order schemes together with multiscale methods to solve multiphase flows in petroleum reservoir has not been explored in literature. In this paper, the Multiscale Restricted Smoothed Basis (MsRSB) method coupled with a MultiPoint Flux Approximation with a Diamond stencil (MPFA-D) is used to solve the elliptical pressure problem while the hyperbolic saturation equation is solved using the high resolution nodal Correction Procedure via Reconstruction (CPR) method. We use the IMPES (Implicit Pressure Explicit Saturation) coupling strategy and a velocity reconstruction operator based on the lowest order Raviart–Thomas interpolation functions. In addition, a hierarchical Multidimensional Limiting Strategy (MLP) is employed in the reconstruction stage of CPR formulation to suppress numerical oscillations (under and over shoots) intrinsic to the representation of shock regions by high-order schemes and to deliver high resolution in smooth regions. To properly couple the MsRSB method with the CPR formulation, an adequate velocity reconstruction throughout all control volumes is necessary to assure the accuracy of the high order method. Thus, the velocity field must present a proper degree of accuracy that, in general, is not handed by multiscale methods. To deal with this issue and to remove the high frequency components of the error and the residual, we have implemented several smoothers. Hence, the aim of this paper is to describe the strategies to couplle of the MsRSB method with CPR and for the first time in literature to analyze the behavior and efficiency of different smoothers applied to the elliptical problem in order to produces accurate velocity field and so proper two phase flow results.

**Keywords:** MPFA-D, High-order CPR Methods, MsRSB, Smoother.