XVIII International Conference on Water Resources
CMWR 2010
J. Carrera (Ed)
CIMNE, Barcelona 2010

UPSCALING RESERVOIR SIMULATION USING MULTILEVEL OPERATOR COARSENING

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Summary. In this work a novel approach for reducing the cost of computations in reservoir simulation is proposed. The main idea is application of wavelets in compressing the fine operators arising from discretisation of pressure equation in fluid flow simulation. For that, wavelet transform as approved and accredited tools in image processing are used. The principles of wavelet transform are splitting the fine format of data into two sets of coarse scale averages and hierarchy of controllable and analysable sets of differences (fluctuations). This gives the ability to filter down the noise, therefore denoising, filtering and compressing the data are among the image processing desirable wavelets applications, however for upscaling purposes such crude transformations of physical properties (absolute permeabilities and porosities) cause errors due to averaging. Instead of direct transformation, a multigrid-style operator coarsening is considered. In this way, the fine complexities of flow are incorporated into the fine finite difference-based cell-center operator, guaranteeing that the subgrid effects are not neglected altogether. The finite difference discretization provides transmissibilities and wavelets transform them into coarse transmissibilities through a matrix multiplication which is explained in the text. The coarse scale transmissibilities obtained in this fashion retain both convergence properties of the fine operator and conservation of mass between coarse blocks. The incompressible water flooding scenario has been the main emphasis in our simulations. The application for two-phase flow simulation is also readily extended by including the mobilities into the fine operator. For a fine saturation profile any fine scale flux reconstruction procedure such as nested gridding is achievable on the conservative coarse scale fluxes.

A series of evaluation of upscaling performances on correlated log-normal absolute permeability fields has been carried out and existing variety of approaches including modified harmonic-arithmetic method, renormalisation method , pressure solve method and iterative local global upscaling have also been accounted in comparison. The study continues with a synthetic channelised model of severe diagonal flow, a shale-included system and also the layers of SPE10 comparative models. The cost was determined by CPU run time.