Received: 1 April 2018 | Revised: 10 August 2018 | Accepted: 10 October 2018

DOI: 10.1002/nag.2872

RESEARCH ARTICLE

WILEY

An enhanced ensemble Kalman filter scheme incorporating model error in sequential coupling between flow and geomechanics

Edison Caballero[1] | Fernando A. Rochinha[1] | Marcio Borges[2] | Marcio A. Murad[2]

[1]Mechanical Engineering Department, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

[2]Computational Mechanics Department, National Laboratory for Scientific Computing, Petrópolis, Brazil

Correspondence
Fernando A. Rochinha, Mechanical Engineering Department, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.
Email: faro@mecanica.coppe.ufrj.br

Summary

In this work, we construct a new methodology for enhancing the predictive accuracy of sequential methods for coupling flow and geomechanics while preserving low computational cost. The new computational approach is developed within the framework of the fixed-stress split algorithm procedure in conjunction with data assimilation based on the ensemble Kalman filter (EnKF). In this context, we identify the high-fidelity model with the two-way formulation where additional source term appears in the flow equation containing the time derivative of total mean stress. The iterative scheme is then interlaced with data assimilation steps, which also incorporate the modeling error inherent to the EnKF framework. Such a procedure gives rise to an "enhanced one-way formulation," exhibiting substantial improvement in accuracy compared with the classical one-way method. The governing equations are discretized by mixed finite elements, and numerical simulation of a 2D slab problem between injection and production wells illustrate the tremendous achievement of the method proposed herein.

KEYWORDS

data assimilation, ensemble Kalman filter, fixed stress split, model error approximation, reservoir geomechanics, sequential methods

1 | INTRODUCTION

In reservoir engineering, the development of computer models aiming at mimicking coupling between flow and geomechanics in strongly heterogeneous porous media is becoming increasingly important as deeper formations, subjected to considerable overburden, are detected and explored. Recently, several works have addressed the importance of considering the impact of geomechanics on hydrocarbon flows.[1-3] The process of fluid withdrawal induces variations in pore pressure leading to perturbations in the effective stress, and strain fields triggering changes in rock properties, such as permeability and porosity.[4] Such a complex phenomenon gives rise to challenges associated with development and optimization in oil production, requiring intensive and long processing CPU time.

In order to capture the coupled features of the reservoir accurately, along with the geomechanics features of the adjacent formations, several types of coupling have been proposed in the literature. Among them, we can highlight fully coupled method[5,6] and sequential schemes[2,3,7] where the subsystems of flow and geomechanics are solved iteratively. This lat-

