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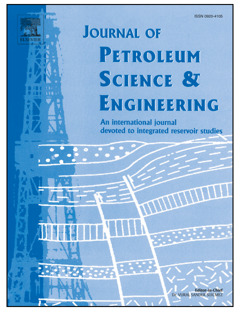

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Uncertainty Quantification and Value of Information Assessment using Proxies and Markov Chain Monte Carlo Method for a Pilot Project

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Abstract

A pilot project is a crucial step of reservoir management that enables the minimization of subsurface risks and improves the quality of decisions on full-field development. Selecting a pilot project involves evaluating the expected uncertainty reduction and the value of information (VOI) attainable from a set of plausible pilot projects. Proxy-based pilot analysis (PBPA) represents a promising approach for characterizing the uncertainty reduction and VOI from each of a set of feasible pilot projects. In the PBPA method, multiple plausible realizations of observed data from a pilot are generated and probabilistic history matching (based on filtering) is performed for each realization of the vector of observed data in order to obtain the corresponding posterior distribution. The multiple history-matching runs are accomplished with a manageable number of simulations with the help of proxies. Previously, PBPA was successfully applied to quantify the expected value of uncertainty reduction in cases where the history-matching tolerance is high, but as shown here, the filtering-based history-matching procedure can fail when the tolerance is low. Moreover, it has not been demonstrated previously that the PBPA method can quantify VOI. In this paper, enhancements to PBPA that eliminate these two PBPA shortcomings are introduced. First, a Markov chain Monte Carlo (MCMC) method is used in place of the filtering procedure to calculate the posterior distribution. The combined MCMC-PBPA procedure is shown to outperform the filtering-based PBPA when the history-matching tolerance is low. Secondly, we define a framework that combines the MCMC-PBPA method with decision tree analysis in order to calculate the VOI. The proposed framework is demonstrated for a synthetic waterflooding pilot in the Brugge reservoir where it successfully quantifies the VOI for different pilot designs.

1 Introduction

In oil and gas field development, pilots refer to small-scale tests and data collection processes prior to a full-field development. For example, before a full-field waterflood development, small-scale injection tests that involve one or more injectors and producers are usually performed to collect data to inform the full-field development decision. Pilot programs play an important role in reservoir management to minimize subsurface risks and to improve decision quality (Teletzke et al., 2008; He et al., 2016a; Chen et al., 2016). The data obtained from a pilot can be assimilated by history matching (Zhang et al., 2016) to reduce the uncertainty of "objective functions" or outcome variables (here, cumulative oil production) that are of interest. However, a pilot project often involves significant capital investment for the new wells, the new facilities and the data