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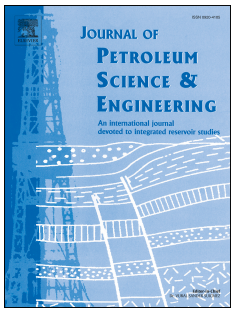

Value-of-information for model parameter updating through history matching

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Manuscript

Value-of-Information for Model Parameter Updating through History Matching

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Abstract

The oil and gas (O&G) industry spends billions of dollars on data (e.g., production data, seismic data and tracer data) gathering and analysis for the purpose of reducing uncertainty and improving their understanding of the most salient features of the subsurface. Yet, the O&G industry spends minimal effort and investment to assess whether the benefit of this data gathering and analysis exceeds the cost. One form of data gathering and analysis is history matching (HM), which has been an essential reservoir management tool for decades. This paper addresses the value of HM by applying the value-of-information (VOI) framework originally developed in the decision sciences.

There are several challenges involved in assessing the VOI in the HM context. Although reservoir management (HM and production optimization) and decision analysis (DA) use many of the same methods, the two domains involve different terminology used in fluid flow modeling and application of state-of-the-art HM and optimization methods. Furthermore, most applications of VOI analysis have focused on static, as opposed to time-dependent, analysis. Finally, some recent publications in the O&G industry that have illustrated and discussed VOI from HM have not been consistent with the original definition of VOI.

In this paper, we illustrate and discuss the use of a consistent, DA-based, VOI analysis framework to assess the VOI in HM contexts. In order to make the VOI framework understandable and accessible to both the reservoir management and DA communities, we provide a "bridge" between the nomenclature and terminology used in VOI calculations and that used in state-of-the-art HM and optimization methods.

The paper includes four VOI analysis examples. The first illustrates the implementation of the general VOI framework for a simple HM problem. The second illustrates and discusses the difference between the calculations presented by other authors and the standard VOI definition used in the DA community. The third illustrates the implementation of VOI calculations in more realistic settings, including a sensitivity analysis of measurement noise. The fourth illustrates the application of VOI assessment in a case where a reservoir simulation model is involved.

1 Introduction

Petroleum engineers and geoscientists involved in reservoir management continually "acquire" information, with the aim of improving decision making. "Information acquisition" is broadly defined here, to cover such activities as acquiring data, performing technical studies, hiring consultants, and performing diagnostic tests. In fact, other than to meet applicable regulatory requirements, the main reason for collecting any information or doing any technical analysis should be to make better decisions. The fundamental question for any information-gathering process is then whether the likely improvement in decision making is worth the cost of obtaining the information. This is the question that value-of-information (VOI) technique is designed to answer.

VOI analysis is an a priori[1] analysis that evaluates the benefits of collecting additional information before one actually gathers the data and makes a decision. Such information gathering might be worthwhile if it could change the decision that would have been made without further information. Although many engineers and geoscientists tend to believe that more information or data is always better, VOI assigns no value to "uncertainty reduction" or "increased confidence" per se. Rather, value is added by enabling the decision maker (DM) to "tune" his/her choice to the underlying uncertainty. Thus, information value is forever an entanglement of uncertainty and decision making; one cannot value information outside of a particular decision context (Bratvold et al. 2009).

[1] "A priori" means "before the data are gathered and interpreted".