Research Group in Reservoir Simulation and Management

Case Study for Field History Matching and Uncertainties Reduction based on UNISIM-II

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Summary

1. Introduction

The aim of this document is to present a reservoir case study for production history matching and uncertainties reduction, entitled **UNISIM-II-H**.

The simulation model (Figure 1) was built based on the reference model **UNISIM-II-R,** developed by Correia et al. (2015) in a second stage (t_H, 3257 days). This model assumes the same characteristics from UNISIM-II-D (until t_D, 516 days), however, with a production strategy definition (after t_D), i.e., UNISIM-II-D was designed for a development phase (t_D) and UNISIM-II-H was designed for a post-development one (t_H). It is a black-oil, dual-perm simulation model with an average grid cell size of 100 x 100 x 8m where the grid type is corner point defined by 65 thousands active blocks. Correia et al. (2015) detailed the construction of the reference model (UNISIM-II-R).

The required data for reservoir simulation using IMEX (version 2017.10) and the case study description are available for download via a web page by interested third parties, such as universities and research centers (www.unisim.cepetro.unicamp.br/benchmarks/unisim-ii/).

The case study has 3257 days (t_2) of historical production data of 20 wells (11 vertical producers and 9 horizontal water injectors).

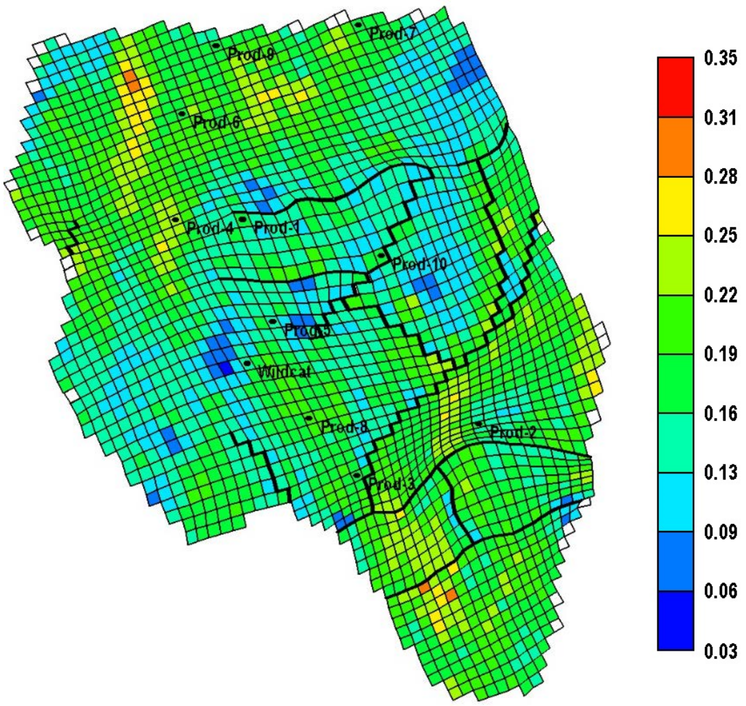

Figure 1: Porosity map (layer 14) for a model with the location of the producer wells.

The objective of the study is to propose data assimilation algorithms considering two approaches:

1) Deterministic history matching from a base model considering the uncertain attributes;
2) Probabilistic approach considering possible uncertainties reduction.

E-mail for questions, comments, suggestions and problems: unisim-benchmark@cepetro.unicamp.br.

2. Problem Description – History Matching and Uncertainties Reduction

2.1 Important Events

This section lists the main field production events of the proposal.

Time (day)	Date (MMM/DD/YYYY)	Event – Field Timeline Description
0	SEP/30/2016	1. Simulation initial date
0	SEP/30/2016	2. Production starting time
516	FEB/28/2018	3. End of production history (t_D)
1247	FEB/29/2020	4. Restart of production - Beginning of well connection (well-platform)
3257	AUG/31/2025	5. End of production history (t_H)
10957	SEP/30/2046	6. Simulation final time (simulation may end earlier but not later) (t_F)

Table 1: UNISIM-II-H timeline events – field production.

2.2 Premises

The decision analysis process is based on the same premises of UNISIM-II-D (www.unisim.cepetro.unicamp.br/benchmarks/br/unisim-ii/unisim-ii-d).

2.3 Deterministic approach

2.3.1 Objectives

The objectives of the deterministic approach are described in the following stages:

(1) Carrying out a history matching until 3257 days (t_H) from the provided base model. Part of the base simulation file is the same supplied in the UNISIM-II-D case (selection of exploitation strategy from t_D – 516 days) with additional information of new wells until t_H.
(2) Carrying out production forecast until the final simulation time (t_F): SEP/30/2046 (10957 days) without modification in the production strategy.
(3) Performing modifications in the production strategy to improve it. Changes will be allowed under project restrictions and premises defined in UNISIM-II-D.

The observed data (well rates and pressure and, field rates and average pressure) are available in the data set. A random noise was added to the observed well data.

For the production prediction (Stages 2 and 3 listed above) all the production strategy characteristics concerning operational restrictions and economic model must be used.

2.4 Uncertainties

For the history matching, the limits of the uncertain attributes described in the UNISIM-II-D should be taken into account. Any modification outside the defined ranges or the addition of new attributes should be reported and justified.

The modifications with respect to the UNISIM-II-D are:

- A new set of petrophysical properties realizations were generated and the model was updated for the post-development phase, using a new package of information as a conditioning data, i.e., new wells were perforated.

2.5 Probabilistic Approach

2.5.1 *Objectives*

The objectives of the probabilistic approach are:

(1) Reducing uncertainty in the production forecast;
(2) Reducing uncertainties of the attributes;
(3) Implementing probabilistic production forecast;
(4) Defining production strategy selection considering the probabilistic approach.

For the probabilistic production forecast, the same aspects described in the deterministic approach, concerning operational restrictions, should be taken into account.

3. Expected Results

The expected project results are:

3.1 History Matching and Uncertainties Reduction

After the history matching and uncertainties reduction, a report should be generated including:

3.1.1 *Deterministic*

a. Attribute values corresponding to the best solution;
b. Process indicator data: chosen methods, number of simulations, computational effort and objective-function evolution;
c. Plots comparing simulated and observed data;
d. Quality indicator: global objective function. Each group should report the global function chosen to measure the matching quality.
e. Matching quality indicator per well: Normalized Quadratic Distance with Sign (NQDS), according to Maschio and Schiozer (2016), for liquid, oil, water and gas rate and pressure for producers and water and pressure for injectors.

If others indicators were chosen in the history matching process, NQDS should be reported for comparison purposes.

3.1.2 *Probabilistic*

a. New likely attributes uncertainty levels indicating possible (acceptable) solutions;
b. Process indicator data: chosen methods, number of simulations and computational effort;
c. Quality indicators for the found solutions: the same one that was previously mentioned.

3.2 Production forecast

3.2.1 *Deterministic*

a. Production forecast until the final simulation time (t_F) keeping the original production strategy unchanged. Only minor modifications, such as, well operational conditions changes and well shut-in, can be done;
b. Indicators:
   i. Primary indicators: net present value (NPV), cumulative oil production (Np) and recovery factor (RF);
   ii. Secondary indicators: cumulative gas production (Gp), cumulative water production (Wp), cumulative water injection (Winj) and average reservoir pressure (Pavg).

3.2.2 Probabilistic

The same indicators corresponding to the deterministic approach should be presented. In addition, a probabilistic analysis, including expected monetary value (EMV) and risk indicators, should be showed.

4. References

1. Correia, M. G.; Hohendorff Filho, J. C. von; Gaspar, A. T. F. da S.; Schiozer, D. J. "UNISIM-II-D: Benchmark Case Proposal Based on a Carbonate Reservoir" (SPE-177140-MS), SPE Latin American and Caribbean Petroleum Engineering Conference, 18-20 November, Quito, Ecuador, 2015.
2. Maschio, C.; Schiozer, D. J. "Probabilistic History Matching using Discrete Latin Hypercube Sampling and Nonparametric Density Estimation", Journal of Petroleum Science and Engineering, v. 147, pp. 98-115, November, 2016.
3. UNISIM-II-D (www.unisim.cepetro.unicamp.br/benchmarks/br/unisim-ii/unisim-ii-d)

5. Provided files

The necessary files for reservoir simulation data are available for download at http://www.unisim.cepetro.unicamp.br/benchmarks/unisim-ii/