

Test Problem

This document presents a description of the test problem and the corresponding data set used to compare ensemble-based methods in the paper: *“Investigation on the sampling performance of ensemble-based methods”* by Alexandre Emerick and Albert Reynolds.

The objective of this data set is to allow other research groups to reproduce the results in the original paper and to test their own implementation and methods. Besides the true model, the data set includes the results obtained with Markov chain Monte Carlo (MCMC) using a very long Markov chain (20 million proposals). The results from this Markov chain were used as reference distributions to compare the results of the ensemble-based methods.

Description

The test problem is a one-dimensional reservoir model under waterflooding (Fig. 1). The number of gridblocks is 31 and the dimensions of all gridblocks are 50 ft × 50 ft × 50 ft. The model parameters are gridblock log-permeabilities, $\ln(k)$. The “true” permeability field (Fig. 2a) was generated using an exponential covariance function with a practical range corresponding to the size of 10 gridblocks. The prior mean of $\ln(k)$ is 5.0 and prior variance is 1.0 for all gridblocks. The porosity is constant and equal to 0.25; the oil viscosity is 2 cp and water viscosity 1 cp. The initial reservoir pressure is 3,500 psi and the compressibility of oil, water and rock are 10^{-5} psi⁻¹, 10^{-6} psi⁻¹ and 5×10^{-6} psi⁻¹ respectively. In this synthetic reservoir, there is a water injection well in the first gridblock which is operated at a constant bottomhole pressure of 4,000 psi. In the last gridblock, there is a producing well operated at a constant bottomhole pressure of 3,000 psi. The observations correspond to gridblock pressures at a monitor well located in the center of the reservoir (gridblock number 16). The historical period corresponds to 360 days, with one pressure measurement every 30 days, which results in 12 data points. We added random Gaussian noise with a standard deviation of 1 psi to the data predicted by the true model to define the

“measurements.” We chose a test case with few data points and small measurement errors to make the problem more challenging for data assimilation. The historical period was defined such that we have water breakthrough at the monitor well but not at the producing well. Fig. 2b shows the water saturation distribution at the end of the history (360 days) and at the end of a forecast period (750 days).

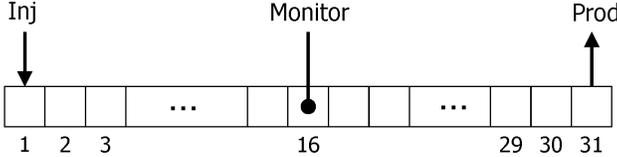


Fig. 1: Gridblocks and well locations.

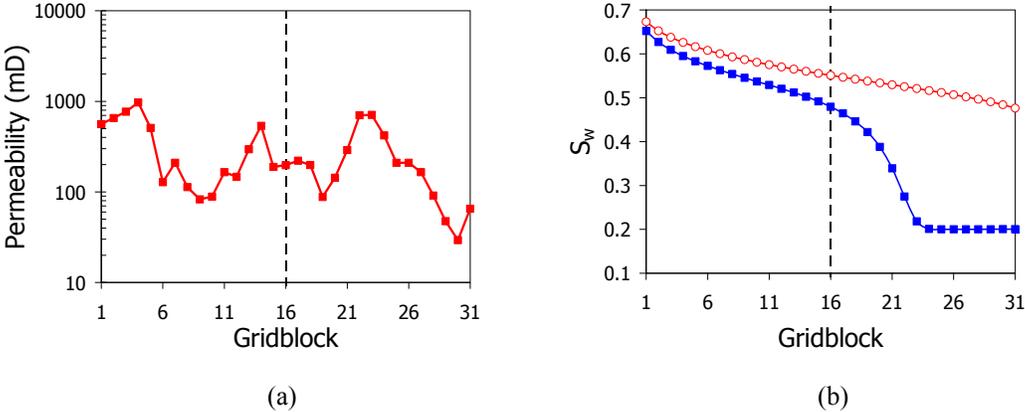


Fig. 2: (a) Permeability of the true model. (b) Water saturation at the end of the historical period (in blue) and at the end of the forecast period (in red). The vertical dashed line indicates the position of the monitor well.

Data set

Description	File name	Comments
Problem description	Problem_description.pdf	This file
True permeability	PERMI_TRUE.inc	Gridblock permeability in mD of the true model.
Prior covariance matrix	Cm.txt	File with prior covariance of log-permeability ($\ln k$).
Simulation files	model.zip	Set of files to run reservoir simulations. It includes the following files <ul style="list-style-type: none"> - model.dat - null.inc - PERMI_TRUE.inc - equilibrium.inc - initialization.inc - recurrent_data.inc - observed_data_press.obs
Reservoir simulator	TwoFlow.exe	2D-2 phase reservoir simulator used in the test problem. It includes adjoint-based gradient for history matching.
MCMC results	MCMC_results.xls	Excel file with main result of MCMC, which are the reference sampling results. This file includes the distribution of permeability (mean, standard deviation and percentiles P2, P25, P50, P75 and P98) and the distributions of predicted data (mean, s.dev and percentiles.)
Prior ensembles	ens_xx.zip	10 initial ensembles of permeability used in the original paper.
Observed data	observed_data.txt	Observed data with noise.

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