

Uncertainty in flow in porous media.

Daniel Busby and Chris Farmer, Schlumberger, Abingdon Technology Centre

Problem:

Our aim is to quantify uncertainty in flow performance prediction due to uncertainty in a reservoir description.

We are able to build a model of uncertainties in the reservoir properties, essentially the porosity and permeability field, based on core samples, well logs and seismic data. From this starting PDF (probability density function) of the reservoir properties we want to estimate the PDF of the results such as the oil production rates and oil present in various regions.

A straightforward approach to this problem is the Monte Carlo method where a big number of realizations, sampled from the reservoir properties PDF, are run with an oil reservoir fluid flow simulator and post-processed to give the final desired PDF.

Due to length of the simulation time this method cannot be really applied in real cases where only a few number of realizations can be simulated in the available time.

A number of different ideas have been pursued in order to solve this problem.

Length scales:

We first want to digress on the important role of the correlation length of our initial random field. In fact we can imagine two opposite situations one in which the correlation length is much smaller than the size of the system and one in which is it of the same order of magnitude. In the first case we can think that the effect of the heterogeneities will be averaged during one simulation and we can expect that the result will not vary sensibly from one simulation to another. In the second case the result of our simulation will depend a lot on the particular realization sampled. This conjecture could be more accurately investigated using numerical experiments.

Numerical Methods:

In order to reduce the simulation time, upscaling techniques are normally used. Various different techniques have been implemented to upscale the reservoir properties to a coarser grid, however these techniques normally rely on the results found running first a simulation on a fine grid. What we are looking for is a way of characterizing uncertainty, so we are not interested in reproducing results found on a fine grid in a coarse grid. Instead we would like to obtain, by running several simulations on a coarse grid, a final PDF of the total oil recovery that approximates the PDF we would obtain by doing simulations on a fine grid.

We wonder if a Bayesian approach could be used in order to relate a large set of coarse grid simulations to a much smaller set of simulations from finer grids.

Analytical methods:

There are also several attempts at analytical approximations to the stochastic partial differential equations of the process.

The major problem is due to the non-linearity of the equations, however very promising results have been found in the case of single-phase flow that could be used as a starting point for two or three-phase problems.

History Matching:

When we study the propagation of uncertainty through a flow simulator we must not forget the important problem that we should condition the probability distribution on observed flow history. Is there some way that this problem, too, can be tackled in a Bayesian framework involving coarse and fine grids?