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Stochastic Reservoir: the Scalar Buckley-Leverett Equation

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Stochastic approach has found broad acceptance in weather forecasting, global climate modeling or hydrology. In the oil business, already in the sixties such tools were used to represent the complex and intricate structure of a porous media. Scheidegger, Matheron Beran were among the people who used such approach to deduce Darcy law at a macroscopic scale, the flow being modeled at the microscopic scale by Stokes equation. A modern revival of such an approach, more mathematically founded, could be the homogenization theory which were developed since the eighties.
In this talk we first present the challenge faced by the reservoir engineer which is supposed to obtain production profiles useful to ascertain the economy of the project under consideration. Most of the time prediction of field performance is based on specific knowledge which is in general a mixture of hard and soft data. Hard data such as logs data collected along the wells, are known with minimal uncertainty, while soft data has a broader spectrum of uncertainties. This uncertainty is managed using geostatistical tools to represent for example, the porosity or the permeability field, between the wells: in this way we obtain stochastic fields which are the coefficients of the equations modeling the flows in the field. Each realization of these stochastic processes gives a possible geological model as an input for the reservoir simulator. But each such model could be very large (million of cells) to conform the hard data at the well. Ensemble-based prediction is then hindered by the computational cost of running a flow simulation on a single geological realization.
This talk will then present a simplified flow model known as the Buckley-Leverett model, introduced in the thirties, to face the previous challenge : in that case the cost of a flow simulation is affordable. We will present some prediction results obtained recently by Cho and Lindquist and then using some work by H Holden and N S Risebro we will assess an homogenization problem for the Buckley-Leverett model extending previous work by T Hontans and P Terpolilli to multiphase flows.