Dynamic Data Integration on GPUs for forecasting porous media flows

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Abstract: In CO2 sequestration in deep saline aquifers, contaminant transport in subsurface, or oil or gas recovery, we often need to forecast flow patterns. In the flow forecasting, subsurface characterization is an important step. To characterize subsurface properties we establish a statistical description of the subsurface properties that are conditioned to existing dynamic (and static) data. We use a Markov Chain Monte Carlo (MCMC) algorithm in a Bayesian statistical description to reconstruct the spatial distribution of two important subsurface properties: rock permeability and porosity. The MCMC algorithm requires repeatedly solving a set of nonlinear partial differential equations describing displacement of fluids in porous media for different values of permeability and porosity. The time needed for the generation of a reliable MCMC chain using the algorithm can be too long to be practical for flow forecasting. To speed-up the generation of MCMC chains we consider two approaches. In a two-stage MCMC approach, we use a computationally inexpensive coarse-scale model to screen proposals before computing fine-scale simulations at a second-stage, resulting in enhanced MCMC performance. With the availability of inexpensive GPUs (Graphics Processing Units), one could also use the pre-fetching algorithm to parallelize an MCMC chain. In this talk, we compare two-stage approach to pre-fetching, without screening, for predictive simulation of two-phase flows in a Bayesian framework.