Stochastic Aquifer Inversion with a New Highly Scalable Parallel Solver

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Abstract. The scope of this paper is to significantly improve the computation efficiency of a new physical-based stochastic inverse method. First, to improve the condition number of the inversion coefficient matrix, coordinate transform and Gaussian Noise Perturbation techniques were implemented, which results in a speedup of 300X by calling the same serial iterative solver. Then, to further improve the speed of the iterative solution therefore the inverse problem can be scaled up to much larger grids, a highly scalable parallel solver was developed and implemented. With the parallel solver, it took only 150s (CPU time) to invert a 500×500 problem with 100 processors. A parallel scaling study further reveals that ideal speedup was achieved in solving the inversion matrices. Moreover, model reduction is explored to understand the computation-resolution trade-off in inversion. Using error-free observation data sampled from 12 wells (e.g., facies types, hydraulic heads, and fluxes) of a groundtruth model, inversion was carried out with three grids with different heterogeneity resolutions, i.e., a geostatistical facies grid generated with Sequential Indicator Simulation (SIS), a Simulated Annealing (SA) grid with smoothed heterogeneity, and a coarsened gird based on the SA grid. Using the serial iterative solver, the average CPU time for solving these inverse problems was 700s (SIS), 450s (SA), and 350s (coarsened). Compared to the true values, the distributions of Ks exhibit increasing biases: 0.5% (SIS), 1% (SA), 5% (coarsened); the bias of recovered BC was 1% (SIS), 2% (SA), 5% (coarsened).