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A TRUNCATED LEVENBERG-MARQUARDT ALGORITHM FOR THE CALIBRATION OF HIGHLY PARAMETERIZED NONLINEAR MODELS

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Summary. We propose a simple modification to the Levenberg-Marquardt minimization algorithm for a more robust and more efficient calibration of highly parameterized, strongly nonlinear models of multiphase flow through porous media. The new method combines the advantages of truncated singular value decomposition with those of the classical Levenberg-Marquardt algorithm, thus enabling a more robust solution of underdetermined inverse problems with complex relations between the parameters to be estimated and the observable state variables used for calibration. The truncation limit separating the solution space from the calibration null space is re-evaluated during the iterative calibration process. In between these re-evaluations, fewer forward simulations are required to calculate the approximate sensitivity matrix. Truncated singular values are used to calculate the Levenberg-Marquardt parameter updates, ensuring that safe small steps along the steepest-descent direction are taken for highly correlated parameters of low sensitivity, whereas efficient quasi-Gauss-Newton steps are taken for independent parameters with high impact. The performance of the proposed scheme is demonstrated for a synthetic data set representing infiltration into a partially saturated, heterogeneous soil, where hydrogeological, petrophysical, and geostatistical parameters are estimated based on the joint inversion of hydrological and geophysical data. This work was supported by the U.S. Dept. of Energy under Contract No. DE-AC02-05CH11231.