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Solution of Inverse Problems in Saturated Groundwater Flow Using Proper Orthogonal Decomposition (POD)

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ABSTRACT

The forward solution of saturated flow problems in the subsurface is a well studied problem. However, the geometry of a reservoir or aquifer often necessitates a full 3D model. Realistic hydraulic permeability distributions from geo-statistics often further introduce a great deal of heterogeneity into the associated properties and locations of material layers. These and other factors quickly increase both the computational cost and the time needed to find a numerical solution. This is true as well for the inverse problem. Given some measurements, such as flow rates or hydraulic head, can any information about the hydraulic permeabilities be determined?

We seek to reduce the computational costs associated with this inverse problem, i.e., approximating material distributions in saturate flow regimes. We will employ a reduced order model derived with Proper Orthogonal Decomposition (POD) in our least squares optimization. Instead of building the reduced model with snapshots as is common in other implementations of POD, we will use the sensitivity vectors. To model the groundwater flow, we will use the 3D finite element software ADH, which was developed at the US Army ERDC. We will also use PEST, a Levenberg-Marquardt least squares solver as the optimizer. Results will be demonstrated in a heterogeneous 3D soil column. It will be shown that the solutions generated using the POD reduced model are comparable in residual norm to the solutions formed using only the full-scale model.