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Parameter Estimation and Sensitivity Analysis in Groundwater Flow

Vitor Nunes and Jeff Borggaard
United States (vitor@vt.edu)

Sensitivity Analysis and Uncertainty Quantification when combined can prove to be very helpful by enabling a more thorough study of Groundwater Flow modeling. The first one studies the effects that the parameters produce on the model's output; the second provides information about their uncertainty.

In previous works, we have proposed a number of methods for identification of the most significant parametric variations, as well as an optimization-based framework for estimation of distributed parameter. This work combines these two approaches. We use the Fréchet derivative to determine the most significant (deterministic) parametric variations; this is used to generate a low order Karhunen-Loeve expansion of the unknown parameters specific storage and hydraulic conductivity. This expansion is used in the parameter identification problem, which is formulated as an infinite dimensional constrained optimization problem.

The low order expansion allows us to estimate the infinite dimensional problem by a smooth, albeit high dimensional, deterministic optimization problem, the so-called "finite noise" problem, in the space of functions with bounded mixed derivatives. We will use a power method and sensitivity equations to evaluate the most significant directions, and compute reduced representations of the operator for efficient gradient calculations. We illustrate our methods with a Groundwater Flow numerical example.