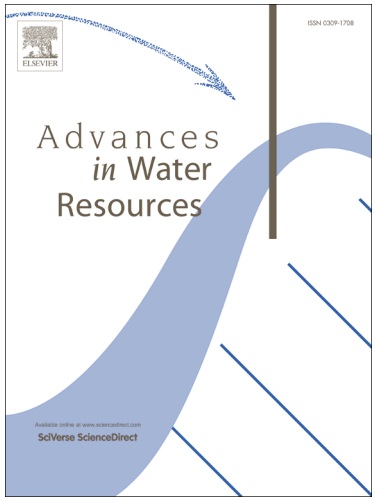

Direct forecasting of subsurface flow response from non-linear dynamic data by linear least-squares in canonical functional principal component space

Aaditya Satija, Jef Caers

PII: S0309-1708(15)00004-4
DOI: http://dx.doi.org/10.1016/j.advwatres.2015.01.002
Reference: ADWR 2316

To appear in: *Advances in Water Resources*

Received Date: 24 August 2014
Revised Date: 2 January 2015
Accepted Date: 4 January 2015

Please cite this article as: Satija, A., Caers, J., Direct forecasting of subsurface flow response from non-linear dynamic data by linear least-squares in canonical functional principal component space, *Advances in Water Resources* (2015), doi: http://dx.doi.org/10.1016/j.advwatres.2015.01.002

Direct forecasting of subsurface flow response from non-linear dynamic data by linear least-squares in canonical functional principal component space

Aaditya Satija & Jef Caers

Energy Resources Engineering, Stanford University, USA

Abstract

Inverse modeling is widely used to assist with forecasting problems in the subsurface. However, full inverse modeling can be time-consuming requiring iteration over a high dimensional parameter space with computationally expensive forward models and complex spatial priors. In this paper, we investigate a prediction-focused approach (PFA) that aims at building a statistical relationship between data variables and forecast variables, avoiding the inversion of model parameters altogether. The statistical relationship is built by first applying the forward model related to the data variables and the forward model related to the prediction variables on a limited set of spatial prior models realizations, typically generated through geostatistical methods. The relationship observed between data and prediction is highly non-linear for many forecasting problems in the subsurface. In this paper we propose a Canonical Functional Component Analysis (CFCA) to map the data and forecast variables into a low-dimensional space where, if successful, the relationship is linear. CFCA consists of (1) functional principal component analysis (FPCA) for dimension reduction of time-series data and (2) canonical correlation analysis (CCA); the latter aiming to establish a linear relationship between data and forecast components. If such mapping is successful, then we illustrate with several cases that (1) simple regression techniques with a multi-Gaussian framework can be used to directly quantify uncertainty on the forecast without any model inversion and that (2) such uncertainty is a good approximation of uncertainty obtained from full posterior sampling with rejection sampling.

Keywords: inverse modeling, functional data analysis, canonical correlation analysis, groundwater, reservoir modeling