



## **Field-scale application of Ensemble Kalman filter assimilation of transient groundwater flow data via stochastic moment equations**

Marco Panzeri (1), Monica Riva (1,2), Alberto Guadagnini (1,2), and Shlomo P. Neuman (2)

(1) Dipartimento di Ingegneria Civile e Ambientale, Politecnico di Milano, Piazza L. Da Vinci 32, 20133 Milano, Italy, (2) Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona 85721, USA

The ensemble Kalman filter (EnKF) enables one to assimilate newly available data in transient groundwater and other temporal earth system models through real-time Bayesian updating of system states (e.g., hydraulic heads) and parameters (e.g., hydraulic conductivities). It has become common to treat spatially varying hydraulic conductivities as autocorrelated random fields conditioned on measured conductivities and/or heads. Doing so renders the corresponding groundwater flow equations stochastic. Assimilating data in such equations via traditional EnKF entails computationally intensive Monte Carlo (MC) simulation. We have previously illustrated a methodology to circumvent the need for MC. Our methodology is grounded on (1) an approximate direct solution of nonlocal (integrodifferential) equations that govern the space-time evolution of conditional ensemble means (statistical expectations) and covariances of hydraulic heads and fluxes and (2) the embedding of these moments in EnKF. This provides sequential updates of conductivity and head estimates throughout the space-time domain of interest, does not suffer from inbreeding issues and, as an additional benefit, obviates the need for computationally intensive batch inverse solution of the moment equations as we have been doing previously. We compare the performance of our new EnKF approach based on stochastic moment equation and of the traditional Monte Carlo approach. We do so for a field scale scenario involving a sequence of pumping tests performed in a heterogeneous alluvial test site located near the city of Tuebingen, Germany.