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Quantification of Parameter Uncertainty of a Distributed Hydraulic Model Using Ensemble Smoother

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Yanqi basin is an important agricultural region in Xinjiang, in Northwest China. The irrigated agricultural land has been increasing in the past decades and made the basin suffer from many environmental problems such as soil salinization, decreased lake level, deteriorated lake water quality, decreased surface water flow to the downstream and damaged riverine forests. A 3-dimensional distributed numerical flow and transport model is built using MIKESHE/MIKE11 which contains saturated and unsaturated zones, rivers and lakes. It allows to better understand the impacts of individual hydrological units and their interactions. Before using the model for quantifying solutions for the environmental problems, the parameter uncertainties of the complex distributed model are assessed using an Ensemble Smoother (ES). ES is a data assimilation method to improve an ensemble of prior parameters by assimilating time series of observations over the whole time period available. It is basically a stochastic calibration method. In this case study, an iterative ES is applied, called Ensemble Smoother with Multiple Data Assimilation (ESMDA) (Emerick and Reynolds, 2012). Two alternatives are considered to update parameters in each iteration. One is the Ensemble Kalman Filter with perturbed observations and the other is an Unbiased Square root filter which updates parameter means and perturbations separately. Seventeen parameters are chosen from the distributed flow and transport model to quantify their uncertainty. Fifty prior replicates of each parameter are generated using the Latin Hypercube Sampling method. The distribution of posterior parameters and outputs obtained from the alternative methods are similar. The results indicate that the uncertainty of the parameters is narrowed during the smoother updating process, reflecting the information obtained from the observations. The most sensitive parameters are the dispersion coefficient of the lakes and the hydraulic conductivity of the aquifer, while other parameters such as the van Genuchten parameters and the dispersivity in the unsaturated zone are insensitive and don't benefit from measurement information. The correlation coefficients among the different parameters increase in each iteration, although they remain small. Both methods converge in two iterations.