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Sensitivity analysis of state and hydraulic conductivity estimates obtained using an Ensemble Smoother to hydraulic conductivity mean and variance errors

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Hydraulic conductivity (K) has considerable spatial variability and since it is measured indirectly, its estimates have high uncertainty. Estimating aquifer parameters, such as K, with certainty allows generating more certain groundwater flow and contaminant concentration predictions through numerical models. For that reason, producing good K field estimates is very important for groundwater modelers. With the increase in the number of devices that allow measuring hydraulic head (h) in real time and with more options and technologies for collecting groundwater contaminant concentration (c) samples, methods to estimate aquifer parameters using that kind of data, on top of K data, can be very useful. On the other hand, it would be a plus if it is possible to estimate h and c at the same time. The ensemble smoother (ES) was proposed by van Leeuwen and Evensen in 1996 and tested with a two-layer nonlinear quasigeostrophic model for Eddy-oceanographic current interactions; the sources of uncertainty considered in the model were initial conditions and measurement errors. The ES is similar to simple kriging in space and time, using an ensemble representation for the space-time error covariance matrix. Herrera, in 1998, developed independently a version of this method for space-time optimization of groundwater quality sampling networks. To our knowledge this was the first work in which an ES was used in the groundwater literature. In previous developments Briseño and Herrera extended the ES proposed by Herrera, to estimate the logarithm of hydraulic conductivity (lnK), together with hydraulic head (h) and contaminant concentration (c), and illustrated its application in a synthetic example. The method has three steps: 1) Given the mean and the semivariogram of lnK, random realizations of this parameter are obtained through Latin Hypercube Sampling; 2) The stochastic model is used to produce hydraulic head (h) and contaminant (c) realizations, for each one of the conductivity realizations, with these realizations the space-time cross covariance matrix lnK-h-c are obtained; 3) Finally, the lnK, h and c estimates are obtained using the ES. Since usually the parameters of the semivariogram of lnK are not known perfectly, the main objective of this work is to analyze the sensitivity of these estimates when two of these parameters, the mean and variance of lnK, have errors. Some case studies were established to estimate lnK, h and c using different data sets that can include h and/or c measurements. The results indicate that the sensitivity of the ES estimates for lnK, h and c using h and c data, is small.

Keywords: Parameter estimation, groundwater transport models, Ensemble Smoother, stochastic models.