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Sensitivity analysis of state and parameter estimates obtained using a space-time ensemble Kalman filter for groundwater transport models

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The main objective of the groundwater quality or piezometrics monitoring networks is to carry out assessments of groundwater quality and/or heads and their variation over time. In the design of this type of networks, a method that involves space and time in a combined form was proposed by Herrera (1998). The method was applied later by Herrera et al (2001) and by Herrera and Pinder (2005). To get the estimates of the contaminant concentration or piezometric levels being analyzed, this method uses a space-time ensemble Kalman filter, based on a stochastic flow and transport model. Because when the method is applied it is important that the characteristics of the stochastic model be congruent with field data, in previous works Briseño and Herrera (2010) and Herrera and Briseño (2010) extended the space-time ensemble Kalman filter proposed by Herrera, to estimate the logarithm of hydraulic conductivity (ln K), 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 ln K, random realizations of this parameter are obtained through Latin Hypercube Sampling (LHS) (for an explanation of the method se Simuta-Champo and Herrera, 2010). 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 mean of ln K, h and c are obtained; for h and c, the mean is calculated in space and time. Also, the cross covariance matrix ln K-h-c is calculated in space and time. 3) Finally the ln K, h and C estimates are obtained using the space-time ensemble Kalman filter. Since usually the parameters of the semivariogram of ln K are not know 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 ln K, have errors. Two case studies were established to estimate ln K, h and c using different data sets. For case 1, different values of the K mean were used (0.4, 0.8, 1.2, 1.6, 2.0, 2.4, 2.8, 3.2, 3.6 and 4.0 m/day) and ln K variance was constant, equal to 1.0. For case 2, different values of ln K variance were used (0.50, 1.0, 1.25, 1.50, 1.75, 2.0, 2.50 and 3.0) and the K mean was constant, equal to 1.6 m/day. The results indicate that the sensitivity of the Kalman filter estimates for ln K, h and c using h and c data, is small.
Keywords: Parameter estimations, groundwater quality monitoring networks, ensemble Kalman filter, stochastic models.

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