Geophysical Research Abstracts
Vol. 12, EGU2010-5313, 2010
EGU General Assembly 2010

Simultaneous updating of spatially distributed hydraulic conductivities and leakage coefficients with the Ensemble Kalman Filter. Application: Zurich, Switzerland.

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The aquifer of the upper Limmat Valley in the city of Zurich (Switzerland) is exploited intensively for drinking water purposes. The well field is located close to the city centre and artificial recharge from basins and infiltration wells should protect the pumping wells against contamination from the city. The aquifer gains important amounts of water from the river, and also receives some lateral inflow and recharge from net precipitation. A 3D variably saturated subsurface hydrological model was developed for the area, which takes river- aquifer interaction into account. The Ensemble Kalman Filter is used to update hydraulic heads in real-time and to provide predictions for the next 10 days.

The simulation experiments showed that the characterisation of the hydraulic head distribution was considerable improved if piezometric data were assimilated, as compared with a calibrated model that was not updated in real-time. Predictions for a longer time horizon (10 days) were also improved with help of the assimilation of observations. If both states and parameters (spatially distributed hydraulic conductivity and leakage coefficient) were updated, predictions were better than without updating; the mean absolute errors for the 1-day and, especially 10-day hydraulic head predictions were reduced, both at assimilation locations and verification locations. In order to explore whether parameter estimates also improved a synthetic experiment with the model for the Limmat valley aquifer was carried out. The synthetic model used one specific stochastic realisation as reality, while forcings, initial and boundary conditions were not modified. In these experiments, too, the best results were obtained if both hydraulic conductivity and leakage coefficient were updated. The parameter estimates improved arriving at a reduction of the mean absolute error of up to 30% for hydraulic conductivity and 60% for the leakage coefficient. Better results were obtained if more stochastic realisations were used and if the parameter values were not updated too frequently. A larger number of stochastic realisations and not too frequent updating limit the impact of sampling errors of the estimated numerical covariances.