Geophysical Research Abstracts
Vol. 16, EGU2014-3760, 2014
EGU General Assembly 2014

Increased reliability of mean travel time predictions of river-groundwater exchange fluxes using optimal design techniques

Thomas Wöhling (1,2), Moritz Gosses (1), and Karsten Osenbrück (1)

(1) University of Tübingen, Water & Earth System Science (WESS), Institute for Geoscience, Tübingen, Germany (thomas.woehling@uni-tuebingen.de), (2) Lincoln Agritech Ltd, Private Bag 3062, Hamilton, New Zealand.

In this study, we follow up on previous work at the Steinlach test site (Osenbrück et al, 2013) near Tübingen, Germany, to investigate hyporheic exchange fluxes in a shallow riparian aquifer. A steady-state MODFLOW model has been developed for the site and calibrated using an existing network of 14 observation wells. Due to a relatively steep hydraulic gradient (0.012 m/m) between the upstream and downstream flow stages of the river bend, water infiltrates from the river into the shallow aquifer along the upstream section of the river and is forced to re-enter the river at the downstream end. The passage through the aquifer potentially allows for mitigation and transformation of river water-bound pollutants. One important factor to estimate attenuation potentials are travel (and exposure) times through (parts of) the aquifer.

In our approach we used forward particle tracking (MODPATH) and a flux-weighting scheme to estimate travel time distributions for the river-groundwater exchange fluxes in the study domain. Travel times vary significantly within the domain, however, estimates of mean travel times derived from deconvolution of EC and $\delta^{18}O$–H_2O data at selected wells exhibit a consistent pattern with modelled travel times. The flux-weighted mean travel time of all river water that passed the riparian aquifer was calculated to 26.1 days.

The uncertainty of the flux-weighted mean travel time was calculated using the prediction error variance approach by Moore and Doherty (2005) which resulted in a post-calibration uncertainty of $\pm$93.5 d (1σ), i.e. about 350% of the actual prediction. We further analysed the worth of potential new observations to reduce the large uncertainty of this model prediction. In our optimization framework, we extend the method by Moore and Doherty (2005) to simultaneously optimize multiple observations using a modified Genetic Algorithm (GA) that can also sample from past states for higher efficiency. The observations considered are hydraulic head, hydraulic conductivity, and river bed conductance.

Our results show that hydraulic head observations have the largest utility to reduce predictive uncertainty for up to two new observations while hydraulic conductivity and bed conductance have the largest utility for monitoring designs with more than two new observations. The optimized design with new 10 observations significantly reduced predictive uncertainty to a value $\pm$3.6 d (1σ), which is a meaningful value for further analysis.

References

Moore, C., and Doherty, D. (2005). Role of the calibration process in reducing model predictive error. Water Resources Research 41(5), W05050.

Osenbrück, K.; Wöhling, Th.; Lemke, D.; Rohrbach, N.; Schwientek, M.; Leven, C.; Castillo Alvarez, C.; Taubald, H. & Cirpka, O. (2013). Assessing hyporheic exchange and associated travel times by hydraulic, chemical, and isotopic monitoring at the Steinlach Test Site, Germany. Env. Earth Sci. , 69, 359-37.