

## ***Interactive comment on “Is inversion based high resolution characterization of spatially heterogeneous river bed hydraulic conductivity needed and possible?” by W. Kurtz et al.***

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Received and published: 4 July 2013

**Dear referee,**  
**We thank you for your helpful comments and suggestions. Here are our replies:**

*In my understanding, in all scenarios the only source of uncertainty taken into consideration is the spatial distribution of the river-bed conductance. All other hydrogeological parameters, for example, the hydraulic conductivity (K) field and the coefficients of the soil moisture and relative hydraulic conductivity laws, are known deterministically. I*

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*find this assumption rather unrealistic, so much so it may be very difficult to translate the results of this work to more realistic scenarios. My major concern is that in a (very likely) situation where, for example, also the K field in the aquifer was unknown, it would be hard to narrow down the L distribution using head measurements alone, as the K-L correlation would be masked by the much stronger K-H correlation. In that case, the answer to the question in the title would be closer to a NO than to a YES. It would be very useful if the Authors cast some light on this potential problem in the discussion.*

**You are right in saying that the only source of uncertainty in our simulation comes from the unknown leakage parameters. The rational behind this was to focus specifically on river-aquifer exchange and leakage parameters because adding additional sources of uncertainty would make the comparison of different ensembles less straight forward. The mass balance of our model is heavily influenced by river-aquifer exchange (due to the pumping close to the river) and therefore a strong correlation between leakage parameters and groundwater levels is present. It is probably not feasible for us to repeat all simulations with uncertain K values but in order to rule out concerns about the role of uncertain K values we will at least repeat one assimilation experiment for scenario A also with uncertain K fields and compare the results with the deterministic simulations.**

*The results show that the assimilation of 10 measurements produces results comparable to those obtained with the assimilation of 100 measurements. In my opinion this finding is not general but very specific of the adopted model setting, given that the hypothesized correlation scale is quite large (1000-2000 m) with respect to the scale of the system domain (around 7000 m length based on Figure 1). A large correlation scale spreads the effect of measurements to a large distance and thus smaller datasets are necessary. Vice versa, if the correlation scale is smaller, the*

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*number of measurements must be inevitably much larger since their effect is limited to small scales.*

**We agree that our findings for less observation points are somehow dependent on our setup and are also influenced by the correlation length of the river bed properties. Comparisons with respect to observation density are always critical because the effect of available observations is not only dependent on their absolute number but also on the position of observation points and their representativeness. We will mention these problems in the discussion section.**

*3) I found it hard to understand the model setting with a sufficient level of confidence. For example, it seems that the river-bed conductance was in substance generated with a one-dimensional simulator and then projected somehow to the elements of the FE mesh discretizing the trace of the stream. It is unclear if any hypothesis on the transversal L heterogeneity was made. My understanding is that the Authors might have used a single conductance value for each cross-section. However, a close look at Figures 3 and 4 seems also to indicate that multiple values are used for each cross-section. Please clarify these points.*

**Sorry, we did not give sufficient information on the generation of the reference fields. We used 2D isotropic Gaussian fields (spatial extend for Limmat: 7000m × 1000m; spatial extend for Sihl: 2500m × 500m; grid size: 50m). These fields were hooked onto the main axis of rivers Limmat and Sihl respectively. The leakage parameter for each river node was then defined as the value of the grid cell (of the Gaussian field) underlying the river node. We will add this information in the description of the generation of reference fields.**

*4) It would be useful to the Reader to know more about the computational requirements*

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*of running a 3D variably saturated flow model that needs fine characterizations of the unsaturated zones. The computational cost must be significant, given that the test cases presented here appear to have required about 400 simulations (100 for the heterogeneous case and 100 for each of the three zonation schemes) for each of the scenarios A,B, and C, for a total of 1200 model runs.*

**For the whole study, we indeed had a relatively high computational burden. In total we had 140 assimilation experiments (three scenarios with 10 references and 4 ensembles each + the simulations for 10 observation points) which translates into 14000 forward integrations of the flow model. The simulation time for one assimilation experiment (100 ensemble members, 609 time steps) in our case is about 20 hours using 8 processors. This time is about the same for all four ensembles (Zhet, Z5, Z3, Z2). We will add this number as a benchmark for possibly interested readers.**

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 5831, 2013.

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