Hydrology and
Earth System
Sciences
Discussions

Interactive comment on "Updating hydraulic properties and layer thicknesses in hydrogeological models using groundwater model calibration results" *by* A. Lourens et al.

Anonymous Referee #3

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This manuscript discusses a method of estimating vertical hydraulic conductivity and thickness of groundwater aquitards. This topic should be of interest to HESS readers, because resistance of aquitard has not been well studied. The authors seem to have a large database (REGIS) that should be useful for them to pursue their research topic. The manuscript is also well organized. However, I am afraid that the manuscript does not meet the requirements for publishing in HESS, and below are my review comments.

Major Comments:

The methodology presented in this manuscript does not appear to be sound. For

example, the authors presented prior and posterior distribution. I assumed that they used Bayesian approaches, but I did not find anything Bayesian in the text. The authors also talked about maximum likelihood methods, but I did not find anything about the likelihood function as well as observations and simulations used to build the likelihood function. Without such information, it is impossible to evaluate whether this research is technically sound.

Figure 1 seems the basis of the methodology used by the authors, but the figure is really hard to be understood. First of all, what is relative density? It is said in the text that "all depicted densities are proportional to the maximum density of the joint PDF", but I do not see any joint PDF. Figure 1a looks like joint PDF but the legend is for "relative density" not for joint PDF. In addition, Figure 1(a) showed vertical conductivity but Figure 1(b) showed vertical resistance. To convert one variable to the other requires knowing aquitard (aquifer) thickness, but the thickness is not discussed anywhere in the text or the figure. The text in page 4197 is also unclear how to obtain the curves of Figures 1(b) and 1(c) based on Figure 1(a). Figure 1(a) is also questionable. How is Figure 1(a) obtained? How we can know whether Figure 1(a) is justifiable/accurate/reliable? For Figure 1(c), the authors said that it is based on the maximum likelihood. If so, what is the likelihood function? What are the related data and model simulations?

As to the research itself, some assumptions used in this study do not seem to be reasonable. In L1-3 of P4196, the authors assumed that the calibrated resistance is the best estimate of the vertical resistance. This sentence is really confusing. If the assumption is correct, then why did the authors need to estimate vertical hydraulic conductivity, as in the L7-8 of P4208? If I am not mistaken, the authors used the calibrated resistance, but estimated layer thickness. If this is the case, the authors may make it clear and consistent about the goal of their study. However, this may lead to another confusion. If the layer thickness is important, varying it may change the calibrated resistance (or conductance). In this case, the assumption made by the authors is not reasonable any more.

In addition, the authors probably made a number of assumptions, but the assumptions are not discussed. For example, in L10-15 of P4199, it is unclear how the PDF is obtained using kriging results. The authors probably assumed Gaussian distributions, but it is not mentioned anywhere in the text.

The research goal itself is questionable. The authors here separate vertical hydraulic conductivity and layer thickness, and treated the former as a randomly homogeneous field but the latter as a randomly heterogeneous field. But the separation is not needed, if hydraulic head in the aquitard is not of interest. In this case, one can build a pseudo-3D model and only need to calibrate one variable, i.e., the vertical resistance (or conductance).

At last, the manuscript is lack of an evaluation of the results. The authors presented a large number of figures and tables, but did not discuss how reliable the results are. For example, the authors did not present any variograms for readers to evaluate the variogram models shown in Table 5. For estimating the PDF of layer thickness using the kriging method, it requires estimating variogram. However, the estimation requires a relatively large number of data, and such data is always unknown. Based on the description in Section 2.4, it seems that the REGIS database has the data. If so, the authors need to present the sample variograms estimated from the data (not the fitted model in Table 3). More importantly, the authors need to process the data, at least, to investigate whether the layer thickness is Gaussian, because the PDF estimation based on kriging assumes Gaussian distribution.

Minor Comments:

L1-5 of P4201. If there are 475,000 litho-layer thickness at 16,000 borehole locations, it is confusing that the authors said that "no quantitative information is available about the uncertainty of the litho-layer thickness". What kind of uncertainty is the authors discussing here?

It is unclear what subsoil is. What is the difference between soil and subsoil? The

authors also used litho-layers later on. Is it the same as the subsoil?

Spell out PDF when it is used for the first time.

L25 of P4195. Define the variables u and cm, and the function u(cm(u))

Dependence of layer thickness (D) and hydraulic conductivity (K) may not be reasonable.