Hydrol. Earth Syst. Sci. Discuss., 6, C3376–C3379, 2010
www.hydrol-earth-syst-sci-discuss.net/6/C3376/2010/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Coupled hydrogeophysical parameter estimation using a sequential Bayesian approach" *by* J. Rings et al.

J. Rings et al.

j.rings@fz-juelich.de

Received and published: 25 February 2010

Thank you for your very positive and kind review.

1. For Figures 7, 8, and 9 it would have been helpful to include the independently determined parameter values. (Understanding that, in most applications, this information will not be available.)

We agree that this will make it easier to interpret the figure and we will include a mark for the independently determined parameters in the figures.

2. It would have been ideal to show the evolution of the parameter values for TDR and ERT used jointly. At a minimum, I would have like to see how the weights would be calculated for more than one measurement type. That is, how should the mismatches be weighted?

We consider this to be a multi-objective optimization problem. In such a multi-objective optimization, the Pareto front that describes the trade-off between fitting both data types is sought. Of course, it is possible to define a Bayesian model for simultaneous inversion using both data types when appropriate weights are specified for the different data sources. We will add this to the theoretical developments. Such an inversion will converge to some compromise point on the Pareto front of possible compromise solutions. However, we believe that there is no objective way to weight the data in the presence of model structural errors. Therefore, we prefer to investigate the entire trade-off between the two measurement types using a multi-criteria framework. This was done in Huisman et al. (2009) using non-sequential multi-objective optimization. The results show that the results are not entirely compatible, although a good compromise can be obtained.

In the context of this study, it is also clear that the TDR data are far superior to the ERT data because of the large amount of invasive TDR data. The added value of the ERT data is low because these measurements are of a different quality (e.g. non-invasive from the surface). However, we are looking forward to applying the proposed methods in an experimental design framework where a sequential assimilation approach can be used to select the most suitable measurement type from a suite of available techniques. Unfortunately, this data set is not suitable for such an analysis for the reasons outlined above.

3. Would it be possible to combine the TDR and ERT results even though the exper-

iments are not identical? It may be cumbersome, but couldn't you somehow "inform" each model by the evolution of the parameter values from the other model?

Combining the different model runs is difficult when both states and parameters are estimated as in the case of the synthetic example in our study. For the river dike example only parameters are estimated, and in theory it would be possible to switch between different data sources and model runs. It is our feeling that this will probably work in a synthetic studies where all measurement type point (more or less clear) to the same optimal model parameters. In the case of real measurements, a compromise solution between different measurement types typically needs to found. In order to do so, all measurements need to be made at the same time in our concept. We can see the importance of these questions and recognize that future research will need to investigate to what extent this strict requirement can be relaxed.

If you could do this, could you simultaneously consider multiple sections of a time series (e.g.rainfall followed by ET) without having to model the entire time series?

We believe that this is possible when the initial conditions for the multiple sections can be accurately defined without running the entire model (e.g. initial conditions independent of hydraulic parameters to be estimated).

4. Do you need to add data sequentially in time? Specifically, I am thinking about the case where the geophysical model is much more computationally expensive than the hydrologic and you have supporting direct data. Could you run your approach for the direct data and then selectively add geophysical data?

This would require several runs of the filter, as adding data at a certain time weaves the likelihood of this data set into the probability distributions. One could envision using the posterior obtained for the direct data as the prior for the next data type (e.g. geophysical data). With proper storage of the particle properties, one could reuse the model simulations until the first geophysical measurements become available. After that, a new filter run is required to assimilate the remaining geophysical data.

Again, it is our feeling that this will probably work in a synthetic studies where all measurement type point (more or less clear) to the same optimal model parameters. However, when data sources are disparate as is typically the case for actual measurement, we do not yet see how the filter can converge to an appropriate solution. Instead, the results will depend on subjective decisions, such as the order in which the data are assimilated. Obtaining an appropriate compromise solution requires simultaneous acquisition of multiple data types.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 6387, 2009.