Hydrol. Earth Syst. Sci. Discuss., 10, C2015–C2018, 2013
www.hydrol-earth-syst-sci-discuss.net/10/C2015/2013/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Approximate Bayesian Computation in hydrologic modeling: equifinality of formal and informal approaches" *by* M. Sadegh and J. A. Vrugt

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Received and published: 27 May 2013

Interactive comment to the "Approximate Bayesian Computation" by M. Sadegh and J. A. Vrugt

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27 May 2013

We think the comparison of ABC and GLUE is interesting, because on first glance both methods might appear to be similar. However, this is a topic with many subtleties and therefore requires a careful treatment with great attention to detail. Here, we would only like to comment on the use of ABC, because we got the impression that was not applied as it was supposed to.

It is probably a misunderstanding that all the cited "likelihood-free" approaches have been developed "for cases when an explicit likelihood function cannot be justified". Instead, they were developed for situation where the likelihood is intractable, too expensive to be evaluated, or an explicit formulation is not available. In such cases, the numerical technique ABC offers a possible solution: Instead of evaluating the likelihood function, we only have to be able to sample from the likelihood function. Thus, bypassing the evaluation of the likelihood function widens the class of models for which statistical inference can be performed. Nevertheless, we must be willing to make assumptions about the distribution of the errors, i.e. "the data generating process" must be known (see e.g. the first paragraph of Diggle and Gratton, 1984; third paragraph of

Marjoram et al, 2003; Sisson et al., 2007). In consequence, ABC requires a **stochastic** model (see the cited ABC literature).

In our view, this important fact has been overlooked in this paper, because the presented algorithms, apparently do not generate a random sample (e.g. the deterministic model output + random error). Instead, only the output of the *deterministic* model $\mathcal{H}(\theta|\cdot)$ is computed and compared to the observations (fourth line of Algorithm 1, fifth and 18th line of Algorithm 2). This is not valid for ABC, and in contrast to those algorithms cited in the ABC literature.

In summary, we think that it should be clearly stated and discussed that ABC does not free the modeler of making explicit distributional assumptions about the errors. This is a fundamental difference to GLUE. In our view, such a comparison should rather highlight the theoretical and numerical differences between statistical and informal approaches instead of "proofing" equivalence of (modified) algorithms.

Minor points that you might want to consider

First sentence of Section 2: The classical Bayesian approach does not only consider model parameter uncertainty but also uncertainty represented by the error model, for example due to measurement uncertainty. The likelihood function describes the "remaining stochasticity" for given parameter values.

Line 3, page 4748: The normalization constant is required to analytically calculate the mean, variance, etc. However, samples from the posterior can be obtained without it.

Tables 4–6: It is surprising that the coverage of the prediction intervals obtained from Bayesian inference with likelihood evaluation are so overconfident and unreliable while the results with ABC are much better. One would expect, that ABC gives approximately the same results as Bayesian inference.

Throughout the paper: Diggle and Gratton (1984) proposed a "likelihood-free" approach for frequentist maximum likelihood estimation, so it is not a Bayesian approach. Therefore, strictly speaking, it cannot be classified as ABC.