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Hydrology and Earth System Sciences Discussions

Interactive comment on "Is the groundwater reservoir linear? Learning from data in hydrological modelling" *by* F. Fenicia et al.

F. Fenicia et al.

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The authors would like to thank all the reviewers for their careful reading of the manuscript and for their valuable comments. Their revisions helped the authors to understand the points that needed clarification and helped the correction process of the paper. As a result, the paper has been restructured, corrected, and partly rewritten. The major changes concerned the abstract, introduction, discussion and conclusion sections, which have been completely rewritten. The calculations have remained the same, however, the methodology description has been improved, introducing more details when needed, and eliminating redundant explanations.

Answer to comment from B. Schaefli:

The authors believe that part of the criticism to the paper is due to some misunderstandings on the intentions of our work. However, we acknowledge that this misinter-

pretation is due to a lack of clarity in the text and a misleading structure of the paper. We made an effort to clarify our intentions in the revised version. Here we summarize the main objectives of the paper, which have been incorporated in the new version:

The first aim of our work is to show a calibration methodology for a particular model structure that develops an optimal parameter set and an optimal derivation of the storage-discharge relation for the slow reacting reservoir. The methodology is illustrated through the following points.

- We calibrate a model structure with a stepped approach, meaning that in a first calibration stage we calibrate all model parameters with a bias to low flows, and in a second calibration stage we recalibrate some parameters with a bias towards fitting the high flows. As suggested by Reviewer 1, we refer to Hogue (2000) for this approach.

- Within the first calibration stage, we infer from data the behaviour of the slow reacting reservoir of the model, through an iterative procedure. The Storage-Discharge relation is inferred from data, and no a-priori assumption is made regarding its form.

- This procedure is demonstrated by means of an application on one catchment.

Subsequently we apply the methodology to other catchments, and we observe that:

- The methodology works also for those catchments

- In all but one case the S-D relation resulted in a linear relation. The exception was formed by an artificially drained catchment, but also here, the final relation was more linear than the initial one.

This was an outcome that we did not expect beforehand. We consider this a surprising result which we feel should be discussed. In our case studies we observed that the nonlinearity observed in the Storage-Discharge relations could be explained by recharge (throughout the paper, and in particular in the discussion section we make it clearer that we are referring to a specific model). Since the nonlinearity in the storage-discharge relation is often observed (we will give more references in the paper), we

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wonder if in general non-linearity can be explained by recharge (or in reverse mode by capillary rise). Hence the title: Is the reservoir linear? Rather than giving an answer to this question, we formulate it as a question, because the question arose as a result of this study.

Detailed answers to the comments of the reviewer explaining the modifications to the paper are included below.

In the “general comment” session, the reviewer notes the following points: - The work is not well referenced.

We added more references in section 1 (introduction) and in section 7 (discussion), concerning in particular the calibration procedure used, previous attempts of inferring groundwater behaviour from data, and recession studies.

- The case-study specificity of the obtained results is not clear.

Throughout the paper, and in particular in the discussion section, we make it clearer that we don’t claim a generalization of the results.

- The paper should discuss whether the results are conditioned by the used model

This point has been clarified in section 4.4 (Recalculation of the storage-discharge relation) and in the discussion and conclusion sections.

- It would be interesting to show an uncertainty-sensitivity analysis

We agree that it could be interesting; however, we made the decision to leave it out, for the sake of clarity and readability of the paper. We cast the calibration problem in an optimization framework. However, we added more details about the calibration procedure the values of the objective functions for the different calibration stages.

- We make the strong assumption that in general the reservoir is linear.

This is not true. Also in the initial version of the paper, we stated clearly that the

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storage-discharge relation is inferred from the data (e.g. pag 1722 line 4, 1724 line 22), and no a-priori assumption has been made.

- Abstract should be rewritten, section 1 and 2 should be combined and shortened, the conclusion should contain more information

Abstract, introduction and conclusion have been rewritten. Section 2 has been removed. The paper has been reorganized to follow the structure that is above illustrated.

- The language and grammar should be carefully reviewed, there are wrong references to figures and equations, some figures should be removed

We paid more attention to the English, we corrected the wrong references, and removed the figures as suggested.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 1717, 2005.