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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Replication of ecologically relevant hydrological indicators following a covariance approach to hydrological model parameterisation" *by* Annie Visser et al.

Anonymous Referee #1

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Review of the manuscript "Replication of ecologically relevant hydrological indicators following a covariance approach to hydrological model parameterisation" by Visser et al.

In this manuscript, Visser et al. evaluate the ability of the hydrological model GR4J to reproduce multiple hydrological indicators in a study catchment in south-eastern England. In a first step, they create a random set of 100'000 parameter sets from which, in a second step, they select a single parameter set that reproduces various efficiency metrics within acceptable limits. The efficiency metrics include the covariance

between precipitation and streamflow, the covariance between potential evaporation and streamflow, and seven hydrological indicators that were found to be important in the study area. The acceptable limits are defined for each efficiency criteria separately based on the relative importance of a particular criteria in the study catchment. Model simulations from the best parameter set are evaluated by calculating various error metrics for each of the seven hydrological indicators. Finally, results are compared to existing studies by means of discussion.

I like the research questions of this manuscript and I see their relevance for practical implementations in the study area and current research in the domain of ecological flows. I especially like the novel idea of defining variable limits of acceptability based on the importance of efficiency criteria and I think that this is an approach worth to be analysed in more detail. I see the current level of the manuscript as an interesting starting point for a much more extended analysis or an in-depth analysis. Overall, I think the manuscript would benefit from a less generic introduction, which provides the reader a tailored and up to date background on modelling hydrological indicators and therefore sets the foundation for the final research questions. I also think that the research questions themselves should be addressed in more detail to support the final conclusions. The current study set up is very site-specific and it would be interesting to extend the analysis to more catchments to be able to generate more generic conclusions.

I hope that the comments below will be helpful for the authors to improve their manuscript.

General comments

The study aims at evaluating three research questions, which I think are very interesting. However, I have some concerns about the way the research questions are

addressed:

1. Research question 1 is addressed by using one study catchment, one hydrological model, and one parameter set. To make more general conclusions I highly recommend to address the question by using many more catchments or multiple hydrological models. Given the current equifinality-paradigm in hydrology, I also recommend to account for uncertainty by using many parameter sets.

2. Research question 2 about the comparison of various modelling studies is addressed by means of discussion. I am not sure if a discussion is enough to answer a research question. To me a research question should, if possible, be addressed by an analysis. If you wish to keep the comparison of your results with prior studies as a research question, I recommend to compare the studies in a quantitative way. Would it be possible that you contact the authors of the four studies to get access to more information?

3. Research question 3 is again addressed by means of discussion without any explicit analysis. The goal of question 3 is to address the limitations of classical calibration such as i) effect of data uncertainty, ii) effect of thresholds applied to select behavioural parameter sets, and iii) effect of equifinality. I wonder if the current study set up allows to tackle these challenges. For example, it would be important that you could show that your proposed approach is less sensitive to disinformative data than other approaches. Or it would be helpful if you could show/ discuss in more detail how the selection of a threshold (limits of acceptability) in this study is different from other studies. And finally, it would be interesting to see how the proposed covariance approach reduces equifinality compared to other approaches.

Specific comments

1. The authors motivate their research by stating that their approach is a step away from classical calibration. However, I don't understand in which way the proposed approach is different from calibration. I agree that finding acceptable parameter sets by some kind of optimization algorithm is different from finding acceptable parameter sets by a Monte Carlo approach. However, the approaches only differ in the way parameter sets are generated, whereby both approaches require at some stage the selection of parameter sets by means of efficiency criteria. To me, both approaches can therefore be considered as model calibration. A non-calibrated model to me would be one where the 100'000 randomly generated parameter sets are used without making any further selection. To me it would be important that you come up with convincing arguments for the statement that the proposed covariance approach is not a (multi-objective) model calibration.

2. The topic of multi-objective calibration leads me to my next comment. It is multiple times mentioned (e.g. title or research question 1) that a covariance approach was used to determine the most suitable model parameters. If I understand correctly, the final selection of a parameter set is based on the combined evaluation of the covariance between precipitation and streamflow, the covariance between potential evaporation and streamflow, and seven hydrological indicators. I would therefore argue that it is not a pure covariance approach, but rather a multi-objective approach that includes covariance as one out of multiple efficiency criteria. Additionally, I think that covariance can be considered as a classical signature with the novelty that it is not a pure hydrological signature, but rather a hydroclimatic signature. To me, the very interesting part is the fact that the objectives (efficiency criteria) used in this multi-objective function are weighted by their importance. Concluding, I would recommend to replace the term "covariance approach" by a term such as "multi-signature approach" or "multi-objective approach".

3. Is it correct that you select the final parameter set using the information of all 54

years? If yes, this would mean that you use the complete time series to find a parameter set and that there is no validation time period (meaning that all the error metrics are calculated for the calibration period). Since you have such a long time series, I would recommend to split the time series and use one part for an independent validation of the proposed approach.

4. The "calibration" finally leads to the selection of a single parameter set. Why do you use only one parameter set? Is it because there was only one out of the 100'000 parameter sets that was behavioural? If there are multiple behavioural parameter sets I strongly recommend to use all of them. Otherwise, you will need very good arguments for putting all your confidence on a single model output.

5. As far as I understood, hydrological indicators were calculated for each single year. Given that hydrological indicators were shown to be only robust if calculated over many years, how do you think this influences your results? Do you think that the yearly variability of the indicators can obscure/influence the uncertainty coming from the approach?

6. I think it would be worth to spend some time in adapting the introduction. For example, the two first paragraphs are very generic and I am not sure how much information they contain related to your research questions. You could shorten these paragraphs to one/two sentences and then extend the introduction to provide more background on e.g. multi-objective calibration or other studies modelling hydrological indicators.

Detailed comments

1. Abstract: You mention in the abstract that one benefit of the proposed approach is the reduction in overall time-demands. Could you specify what exactly you are

thinking of? The first thing that comes into my mind is that you want to reduce computational time. However, GR4J is a model, which is not very demanding in terms of computational effort. I was therefore wondering if you thought about using a more time-consuming model to proof that the approach does save computational time. This would also need a comparison of a traditional approach to your approach, which, I know, will need quite some time. Of course, you could also just explain or weaken your statement.

2. Study area: You mention that the catchment is an SSSI, that there is significant pressure on the river, and that the river has a highly seasonal flow regime. I think it would be interesting to add a sentence or two saying why the catchment is an SSSI, what kind of pressure sources exist, and how the seasonality looks like (mostly winter streamflow?).

3. Fig. 1: The markers for River Nar and Lexham village are difficult to differentiate in the figure.

4. Fig. 2: I was wondering why you decided to show a Figure of the model structure of GR4J? Given that you don't compare multiple models with different structures or that you don't extensively discuss model parameter values, I think you could remove the figure.

5. Table 2: I suggest to name the last item of the header "relative importance".

6. P6 L18: If I am not wrong, the reference to Fig. A2 comes before the reference to Fig. A1. So maybe you could switch the position of these two figures in the appendix.

7. P7 L4: Could you say specifically which error you minimise between observed and simulated covariance and HI? Is it the percent error?

8. Fig. 4: 1) The y-axis label is “percent error” while the legend says “difference between observed and simulated values” – what is correct? 2) The plot location of the hydrological indicators on the x-axis does not fully agree with the values in Table 2, e.g. Q70Q50 has according to Table 2 a low relative importance while it has a high one in the figure. 3) You use this figure two illustrate the concept of the limits of acceptability and to show the result of the best parameter set. Is there a way you could separate methods and results part in this figure?

9. P8 L6: The first reference you do in the results part is to a figure in the appendix (Fig. A2). Given the importance of this figure, I would suggest to have it in the main body of the manuscript.

10. P9 L7: You mention that you evaluate the model in terms of performance and consistency. I would therefore recommend that you rearrange the results chapter do this evaluation in a very clear way.

11. P9 L25-28: I would delete the first two sentences of this paragraph because they are methods and not results. I would also delete the last sentence of this paragraph and add the reference to Fig. 8 somewhere in brackets.

12. Figure captions: Could you be more specific in the figure captions, i.e. could you for each figure say how many data points are in each plot? I think it is important to guide the reader by telling if e.g. a histogram contains 54 simulation years or n parameter sets.

13. Fig. 5 and Fig. 6: These threes (sub)plots contain very similar information. I recommend to find a way to condense the information into a single figure. In Fig. 5a, what do the numbers in the brackets of the header mean?

14. Fig. 6: The figures contain a relatively small number of points. I was wondering if you can merge the three figures or if a table/ heatmap would be more suitable to show the results?

15. Fig. 8: The figure does not contain a dot for the 0-25 quantile of RevPos. I would suggest that you mention the reason for that in the figure caption and not somewhere in the main text. Maybe you could also plot the dot at the margin of the figure together with an arrow indicating that it is an outlier.

16. P21 L11: The reference to Cramer is not at the correct location and is lacking a year.

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