

Towards reducing the high cost of parameter sensitivity analysis in hydrologic modelling: a regional parameter sensitivity analysis approach

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Response to reviewers comments

The authors thank the Editor and the reviewers for their comments and suggestions. This document provides point-to-point replies to the reviewer 2 comment.

Response to Reviewer 2

RC: In addition to the first round, I have the following comments.

I am not convinced of the reply to my comment with regard to reduce the parameter space by constraining parameter ranges.

I agree with the authors that a reduction of the parameter range would not reduce the number of parameters. However, the title of the manuscript is related to a reduction of the high cost of parameter sensitivity analysis. Thus, overall the study is interested in more efficiency in parameter sensitivity analysis.

And reducing the parameter range (constraining parameters) would, as the authors mentioned in their reply and in the discussion, speed up the search algorithm. However, it reads in the discussion more as it is in principle an option, but is not recommended due to the risk that the optimal solution is not found due to a reduction of the parameter range.

However, a reduction of the parameter range certainly also reduces the parameter space. It is here more the question how to constrain parameter ranges in a reasonable way. Depending on expert knowledge of the model and information about catchment characteristics, a reduction of parameter ranges could reduce the computational cost of parameter sensitivity analysis.

Thus, with regard to more efficiency in parameter sensitivity analysis, it is required to mention all options. Therefore, I recommend the authors to improve this part of the manuscript and to include a more balanced statement.

Response: Thank you for your comment and suggestion. We mention the option of reducing the parameter ranges in the discussion section in a context of a process-based calibration where sensitivity analysis identifies a large number of parameters sensitive to the considered processes (see Lines 502-518). Hence, reducing the parameter ranges is discussed as an option to speed the

calibration process instead of improving the efficiency of the sensitivity analysis. We agree with the reviewer that a reduction of parameter ranges depending on expert knowledge of the model and information about catchment characteristics is useful but in a calibration context (i.e., parameter identifiability). In a sensitivity analysis, the computational cost is mostly tied to the number of parameters and the run time of the model (see Lines 42-44). For instance with the sensitivity analysis approach used here, $10N$ model runs were required on average with N being the number of parameters (see Line 213-214). Therefore, the computational time required is $10N$ x time required to run the model over a specific basin. Therefore, the parameter ranges would not make any difference to reduce the computational cost of the sensitivity analysis. This study is interested in efficiency of sensitivity analysis on large scales due to the computational cost of running hydrologic models over large domains particularly land surface models that have a large number of parameters. Specifically, the objective of the paper is to reduce the cost of identifying the spatial pattern of sensitive parameters over large domains at a reduced cost (see Lines 9-11). The Lines addressing reducing the parameter ranges are revised as follows (Lines 513-517):

Another approach to reduce the complexity of the calibration problem would be to use a smaller parameter range, which could speed the convergence rate of the search algorithm to the optimal solution. However, this would have to be done carefully, possibly utilizing expert knowledge, in order to ensure the narrower range still contains the optimal solution (Mai, 2023).