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Discussions

Interactive comment on "Simultaneous calibration of hydrological models in geographical space" *by* A. Bárdossy et al.

Anonymous Referee #2

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Title: Simultaneous calibration of hydrological models in geographical space

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Overview

This study explores a new method to transfer parameters from gauged to ungauged catchments. It is hypothesized that the parameters of a hydrologic model can be divided into two categories. One category represents the dynamic behavior of catchments while the other represents the long term water balance. The typical parameters of a parsimonious conceptual model are categorized as dynamic and a new parameter (eta) is introduced to represent water balance. This strategy also preserves the overall

structure of the selected models. Parameters that represent the dynamic catchment behavior (all except eta) are estimated through simultaneous calibration and transferred to the (assumed) ungauged catchment while eta is estimated by water balance analysis. It is suggested that other methods (such as regionalization) can be used for identifying eta. The performance of transferred parameters is then assessed through four experiments using various calibration strategies (individual vs. simultaneous), and catchment sets.

Main Comments

The main idea of the study is interesting and worth exploring. However, there are a few concerns regarding the formulation of the water balance parameter, and the resultant parameter transfer strategies. These need to be addressed in order to clarify the main contribution.

1. Can eta effectively separate the dynamic and long term water balance behavior of catchments?

The water balance parameter introduced in Section 4.1 aims to isolate the dynamic and long term water balance related aspects of the hydrograph. The question is whether such a separation can be achieved by this parameter. Eta essentially corrects for water balance error (Equation 7 on Page 11233). Equation 5 on Page 11233 shows that eta achieves this by altering the estimation of actual evapotranspiration at each time step. Therefore, introducing eta is likely to alter the dynamic behavior by changing the amount of water available in the soil moisture bucket (SM in equation 5). If more water evaporates at a time step, less is available in the next time step as soil moisture and vice-versa. Moreover, this effect may increase with simulation time. This affects the eventual runoff response of the catchment that depends upon the antecedent soil moisture conditions. Thus, the parameter introduced to correct for long term water balance will also alter the dynamic behavior of the catchment. To what extent this effect is significant can be assessed by comparing the dynamic performance measures with and without eta in the model structure as introduction of eta may also affect performance criteria such as NS and GK.

2. If eta depends upon the parameter vector, can it be regionalized?

As discussed in Section 4.1 (Lines 22-23 on Page 11233), eta varies with the parameter vector. This implies that eta depends on the calibration process (which determines the parameter vectors) and associated uncertainties in climate variables and streamflow observations. This will be a challenge in its estimation for its ungauged basins.

3. Performance assessment of transferred parameters

There are some issues related to performance assessment criteria of donor and recipient catchments that can be clarified in the text. First, if eta affects the dynamic performance measures such as NS and GK, it should also be transferred to the (assumed) ungauged catchment. However, all the experiments in the study only transfer the dynamic parameters. Second, it is unclear whether the NS and GK measures of the donor catchment are calculated before or after eta is included in the model structure.

Other Comments

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1. Line 6 on Page 11229: Please check this statement. Not all catchments in the MOPEX database are classified as ‘reference’ or minimally impacted.

2. Section 3.4: Since several performance measures are being used, it would be helpful to know the feasible range and ideal values of each performance measure.

3. Line 4, Page 11234: Replace parameters with ‘parameter vectors’.

4. Line 12, Page 11234: Missing space after period.

5. Line 16, Page 11234: Replace weather by climate.

6. Lines 3-4, Page 11235: Replace ‘the models perform differently in different catchments’ with ‘the model performance varies across catchments’.

7. Lines 10-11, Page 11236: Consider rephrasing to: ‘Parameter vectors from other catchments generally fail to perform on catchment 15 across all three models’.

8. Lines 3 and 5, Page 11237: Replace weather by climate.

9. Equation 8: what does index i represent?

10. Lines 24-26, Page 11238: The observation that parameter vectors obtained through common calibration may outperform individual on-site calibration may also indicate the weakness of the calibration process for an individual catchment, which should ideally be able to identify the ’best’ set.

11. Line 16, Page 11239: Remove ‘effective’.

12. Line 19, Page 11239: ‘it outperforms model’, should be ‘it outperforms the parameter vectors’.

13. Section 8, Page 11242: This section and associated results can potentially be removed. It is not clear whether parameter transfer between such disparate regions should be discussed with only two supporting examples.

14. Line 7, Page 11243: What is the meaning of the term ‘deepest parameter’?

15. Section 9.2: Eta likely interacts with parameters controlling the flow generation processes. It is perhaps more useful to focus on the role of eta and explore questions such as how eta alters water balances, how it interacts with bucket size (Cmax) through plots of eta vs. Cmax, etc.

16. Lines 17-20, Page 11243: The estimation of eta seems to be a challenge as it may

be impacted by parameter interactions, observational uncertainties, etc., which cannot be ascertained due to absence of streamflow data!

17. Section 10: The conclusions section can be shortened, and discussion related to the continental parameter transfer removed.

18. Lines 5-11: Consider revising this text.

19. Figure 3: Adding model names on top of the color matrices, or referring to them through labels and legend information would be helpful.

20. Figure 3: Given the scale for GK, which begins from 0.7, it seems there is not much performance variation (or is the variation from 0.7 to 0.95 significant when compared to the variation in NS from negative values to 0.8 in the sub panel above?).

21. Figure 4: Adding model names on the figure or in the legend would be helpful.

22. Figure 5: This figure would be easier to interpret if the entire feasible range of both parameters were plotted instead of the range spanning the dataset. Boxplots or histograms showing the ranges for various parameters may be more useful as several catchments can be shown in the same plot using panels. This figure can potentially be merged with Figure 6.

23. Figure 6: See comment above, can potentially be merged with Figure 5.

24. Figure 17: This figure can potentially be removed.

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