

Interactive comment on “Estimation of baseflow parameters of variable infiltration capacity model with soil and topography properties for predictions in ungauged basins” by Z. Bao et al.

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General comments: This paper evaluates the advantages of reducing the number of parameter prompted to calibration in the VIC baseflow formulation by computing 3 parameters using physically-based equations. Using a Monte Carlo approach the sensitivity of 6(3) model parameters are evaluated in a 6(3)-parameters methodology in 24 basins in China. Results indicate that two parameters, b and d_2 , become more sensitive when the 3-parameter method is used. Also, streamflow uncertainty is reduced with this approached compared to the 6-parameter method.

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The limitations of the current study include: 1- My main concern is related to the number of Monte Carlo simulations used to perform the sensitivity analysis. The Authors do not specify neither the number of simulations nor the sampling method used to perform the analysis. I think the small number simulation is masking the results (based on the plots the number of MC does not seem be to be larger than 100). This can be solved by reducing the number of catchments to 3-4 based on the number of hydroclimatic environments found in China and increasing the number of MC simulations only for those selected basins. 2- The Authors do not show the parameter values obtained using physically-based equations. How the values (W_s , D_s and D_m) compared to the values from the sensitivity analysis? Where the soil and topographic information was obtained? What was the spatial scale of the soil maps and DEM used? 3- The Authors do not point out how efficient the 3-parameter method is compared to the traditional 6-parameter method in terms of computation and time efficiencies. 4- How realistic is to obtain all the physical information needed to calculate parameters W_s , D_s and D_m , especially in poorly-instrumented basins? 5- The Authors fail to convey the advantages, if any, of the 3-parameter methodology over the 6-parameter (conventional) procedure. 6- Figure 6 needs to be explained in detailed or eliminated from the paper. How the authors obtained it? 7- The improvement in parameter sensitivity is minimum, in cases negligible, for the 3-parameter method.

Minor overall comments: -The English needs some improvement but it is overall easy to read. -The paper is clear and flows well. - Summary Section should be Summary and Conclusions - I think Figure1 and 2 could be merged into one figure with two subplots. - I would considerer replacing the 3 parameters methodology by 3-parameter methodology

Despite the above limitations, I think the study is interesting, it presents a nobel approach that have applicability to another basins and hydrological models. The paper needs to address mayor comments before it is ready for publication.

Abstract, lines 1-2: Repetitive sentence. “Equifinality is unavoidable when transferring

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model parameters from gauged catchments to ungauged catchments for predictions in ungauged basins (PUB).” Perhaps replace with: Equifinality is unavoidable when transferring model parameters from gauged catchments to ungauged catchments for hydrologic predictions.

Line 3: it should read: the Variable Infiltration Capacity (VIC) model Line 10: replace “Using the new parameters estimation approach, model parameters become more sensitive and the extent of parameters space will be smaller when a threshold of goodness-of-fit is given” with “Using the new parameter estimation approach, model parameters become more sensitive and the extent of parameters space is smaller when a threshold of goodness-of-fit is given.”

Line 15: it should read: . . . compared to the uncertainty given by the original calibration method”

Introduction Line 19: it should read: . . .is a macro-scale land surface model.

Page 7019: Line 4: remove, vice versa

Line 6: replace “by simulated” with “ with simulated”

Line 19: replace “with regression equations” with “using regression equations”

Line 19: remove: “However”

Line 22: remove: “Meanwhile”

Line 26: replace “Due to above” with “Due to the above”

Line 27: replace “when they are verified” with “when optimized parameters are applied”

Page 7020 Line 1: replace “have been more and more popularly” with “ have been widely”

Page 7021: replace “ compare” with “compared”

Page 7022 Line 3: it should read: . . .is a macro-scale land surface model.

C2999

Line 8: replace “With refined describing of” with “Due to its refined description of”

Line 12: The authors may want to add an explanation of why those two objective functions were selected. Why Nsc and Re, what behavior in the model can they capture?

Page 7023 Line 8: This is no quite right; the VIC model is highly parameterized. There are twenty-one soil related parameters. The six model parameters you mentioned are the most widely parameters prompted to calibration. You need to rephrase this sentence.

Line 11: replace “The six parameters are calibrated by two objectives:” with “Two objective functions are used to measure the goodness of the fitting:”

Line 23: replace “,and has been applied in many researches” with “that has been applied in numerous studies”

Page 7023 Line 5: replace “,using Monte Carlo (MC) method.” With “,using a Monte Carlo (MC) approach.”

Line 10: Why to use the average of the Nsc and Re? It is a reason behind this? It seems to me that you are losing information by doing this average. Please explain.

Line 15: Do you mean small a given threshold?

Line 16: replace “as “nonbehavioral” and is rejected” with “ “nonbehavioral” and it is rejected”

Line 18: Not clear the sentence: “That is defined as likelihood weight looked like probability, and is regarded as the posterior parameters probability distribution.” Do you mean: “ The likelihood weight is defined as probability, and it is regarded as the posterior parameter probability distribution.” ? Please clarify?

Line 20: replace: “with likelihood” with “ with the likelihood”

Line 23: replace” “In addition of confidence interval, a quantitative estimator is used

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for uncertainty analysis” with “In addition to the confidence intervals, a quantitative estimator is used for the uncertainty analysis”

Page 7024 My main comment about this section is the lack of description of the methodology used to sample the parameters used in the analysis. Was it stratified sampling, was it Latin Hypercube, was it uniform sampling? How many Monte Carlo simulations were done? Based on Figure 5 the number of model simulations is quite small (perhaps 100). Nijssen and Lettenmaier (2004) used 1000 MC simulations of the VIC model at a large scale (4500 km²) spanning 6 years at the daily time step (4500 time steps). Demaria et al., 2007 used ~50,000 simulations for a lumped model in a small-scale basin at a daily time step. Line 14: Equation 6. What was the reason to get an average of the Nsc and Re? The advantage of using two objective functions instead of one is to be able to capture the different model responses, i.e., mass balance versus peaks or low flows. Please explain.

Page 7025 Line 5: Your statement: “In VIC model, the three baseflow parameters (Ws, Ds, and Dm) are less sensitive than other three parameters (Demaria et al., 2007)”. Demaria et al., (2007) used a slightly different implementation of the baseflow formulation introduced by Nijssen et al., 2001 (see Nijssen, B., G. M. O’Donnell, D. P. Lettenmaier, D. Lohmann, and E. F. Wood, 2001, Predicting the discharge of global rivers, *J. Clim.*, 14, 3307–3323.). Although this implementation has in principle the same equation, the parameters are different. I think you should mention to avoid confusion to future readers.

Page 7026 Line 15: replace “and are different in different sub-grid.” with “and are different in different sub-grids.”

Line 15: it is not clear what you mean by “But using calibration methodology, parameters will be set as same value in the whole catchment. Therefore, using this framework, baseflow parameters will be distributed and more relatively authentic.” Does it mean in the calibration procedure you a-priori parameter values will be the same for each grid

C3001

cell? What do you mean by “Therefore,). Please clarify.

Line 20: why 24 catchments were used, it seems to me that selecting a large number of basins detracts the quality of the MC sampling, i.e., fewer parameter sampling. Wouldn’t it be more beneficial to use one basin from each represented climate as in (Demaria et al., 2007; Van Werkhoven, et al., 2009. Sensitivity-guided reduction of parametric dimensionality for multi-objective calibration of watershed models. *Advances in Water Resources*, 32(8), 1154-1169.) ?

Page 7027 Line 6: replace “Most available streamflow data are more than 20 yr.” with “Most available streamflow data are archived for at least 20 years.”

Line 14: replace “One is estimating all six parameters through calibration, called 6 parameters methodology. Another one is estimating three baseflow parameters by physical properties of soil and topography, and the remaining three parameters are calibrated, called 3 parameters methodology.” with “The first one consists in estimating One is estimating all six parameters through calibration, called 6 parameters methodology. The second one estimates three baseflow parameters using the physical properties of soil and topography, and the remaining three parameters are calibrated, called 3 parameters methodology.”

Line 15: what are the values of the parameters (Dm, Ws and Ds) that were estimated using physical properties? You need to include them in the paper.

Line 15: how the parameter values computed with equations 8, 9 and 11 compare to the ones obtained through the sensitivity analysis? I would be nice if the Authors include the values in Figure 6 for reference (with a star for example).

Line 18: I think three bar plots showing for each catchment and each objective function the model performance will be a better way to show the results of table 3. You can do 1 figure with 3 subplots.

Line 20: replace “No matter for 6 parameters methodology or 3 parameters methodol-

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ogy,” with “Regardless of the method used: 6 parameters methodology or 3 parameters methodology,”

Line 20: By looking at Table 2 and 3 it is difficult to know what basins are humid and which ones are arid. I recommend adding an additional column in Table 2 showing the Dryness Index (Ep/P). In table 3 it would be useful to order the basins based on the Dryness Index from drier to wetter.

Line 20 to 27: What can be driving the differences in Nsc and RE in the Haihe and Yellow river? Is it climate, is it the size of the basin? Please explain.

Page 7028 Line 8: replace “The model parameters sensitivity is estimated by MC simulation, and the results in three kinds of hydro-climatic catchments: Gaoqitou, Taolinkou, and Minhe catchment, are illustrated in Fig. 5. ” with “The model parameters sensitivity is estimated using a MC approach, and the results for three different of hydro-climatic environments: Gaoqitou, Taolinkou, and Minhe catchment, are illustrated in Fig. 5.”

Line 10: what do you mean by : “ i.e., the model can perform best within an extensive range of parameters space”, please explain

Line 10-11: The Authors need to explain what a Sensitive parameter means? How the reader should interpret Figure 5? Am I looking to a maximum or a minimum for Sensitivity? Please explain.

Line 12: Why parameter b is more sensitive in an arid catchment?

Line 13: Why parameter d2 is the most sensitive one? Please explain

Line 18: I cannot see the increase in sensitivity in parameter d3 for the 3-parameter method. Please explain. The authors may want to revisit (Wagener, T., D. P. Boyle, M. J. Lees, H. S. Wheater, H. V. Gupta, and S. Sorooshian (2001), A framework for development and application of hydrological models, *Hydrol. Earth Syst. Sci.*, 5(1), 13– 26) for details.

C3003

Line 19: what do you mean by: Meantime, some original sensitive parameters become more sensitive. What parameters? Please explain.

Line 20: What are you showing in Figure 6? Are these simulated values? Do you think the differences between Extent 1 and Extent2 are statistically significant? Please explain the figure or remove it.

Line 25: How did you choose the threshold Mnc equal to 0.6? You need to use a different color or shading for the humid and arid basins in Figure 7. It is not intuitive which is the humid basin and which is the arid one.

Page 7029 Line 4-5: the differences in variances between the 3 and 6-parameter method is almost negligible.

Line 23: It would be nice to see the relative change between the 6 and 3-parameters in a third row. For example for Gaoqitou basin: $(310.11-336.39)/336.39*100 = -7.8124\%$ decrease with respect to the 6-parameter method.

Line 24: same comment as above.

Line 4-9. I am concern the differences in the variances are coming from using samples with dissimilar lengths. For example parameter d2 shows more well-behaved simulations in the Humid basin than in the Arid basin, hence the variance in the former will be larger due to insensitivity of this parameter. I think you need to weight the variance by the length of the sample or find another way to measure the variability/

Page 7030 Line 1: Shoudn't it read Summary and Conclusions?

Line 4-5: It is not clear what the Authors mean by: Therefore, the equifinality of the three baseflow parameters is higher than other three parameters.

Page 7031 Line 3-11: I wonder what is more computationally and time efficient, the 3-parameter or the 6-parameter methodology? It seems to me that obtaining the parameter values with equations 8, 9 and 11 can be troublesome and time consuming

C3004

especially in poorly-instrumented basins. I am not convinced that the 3-parameter methodology offers any advantage over the 6-parameter (conventional) procedure because: 1- Improvements in parameter sensitivity is minimum as seen in Figure 6 and 7.

2- Table 4 shows that the accuracy gain is quite small (-7.8124 % for the Gaoqitou basin with respect to the 6-parameter methodology for example) which is smaller than the error in a rating curve (~25%).

3- The number of MC simulations seem to be too small to accurately capture the sensitivity of the parameters.

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