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Hydrology and Earth System Sciences Discussions

Interactive comment on "Towards improving river discharge estimation in ungauged basins: calibration of rainfall-runoff models based on satellite observations of river flow width at basin outlet" *by* Wenchao Sun et al.

Wenchao Sun et al.

wsun.uy@gmail.com

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We are thankful to Mr. Apel for the helpful suggestions and comments he made. The following are our response. Please contact with us if further revision is needed.

Response to the general comments

We also realize that stating the applicability and limitation of the proposed method clearly is very important for interested readers to apply the approach to their own study

area. The remotely sensed river width works as the calibration data of the rainfall-runoff model. Therefore, if we discuss the applicability, the characteristics about the target basin also need to be clarified. Based on our understanding at this moment, the method is feasible for target basins have the attributes as follows:

1. The structure of the selected rainfall-runoff model can properly reflect rainfall-runoff process the target basins (Successful applications in well gauged basins having similar topographic, climatic condition with the target basin may raise the confidence on the model performance).

2. The river discharge gauging is totally unavailable, or observed hydrological data are not accessible.

3. The input and forcing data for rainfall-runoff modeling are available.

4. The variations of river width at the basin outlet are detectable from remote sensing.

5. At-a-station hydraulic geometry is suitable to describe the relation between river width and discharge at the basin outlet. Generally, the reach of the basin outlet should be alluvial and self-formed.

Using hydraulic geometry will obviously have limitations. The Q-W relation is only described by one single rating-curve. Therefore, the cross-section with compound shape (e.g., channel with flood plain), for which inhomogeneous rating curve is needed, is not suitable for the proposed method. Because the Q-W relation is assumed to be constant under the calibration scheme, applications to cross sections that shape changed dramatically in the calibration period are also not appropriate.

As mentioned by Mr. Apel, the value of b is strongly related to the cross-sectional shape. Based on the parameterization scheme of Dingman (2007), for the cross section with triangle shape, the value of b is around 0.4. For rectangular shape, b is 0. The b for most of the other cross-sectional shape is within the range of 0-0.4. However, the reach averaged river width derived from remote sensing, rather than river width at one specific cross-section is used to build Q-W relation in this study. At this moment, for improving our knowledge about this Q-W relation based on remote sensing data, it may be necessary to test the relation in various types of river channel. This study could be considered as one trial.

The statement of applicability and limitation will be added to the revised manuscript.

Response to the specific comments

»In the introduction and discussion it should be mentioned, that remotely sensed inundation extends are meanwhile frequently used in the calibration of hydraulic models, as e.g. in the paper of Montanari et al. 2009. The proposed method is thus an analogy for hydrological models.

Response: Thank you very much for helping us clarifying the background of the proposed method. This part will be added in the revised manuscript.

»P. 3810, bullet point 1: It should also be noted that the hysteresis in the Q-H relation and thus also in the Q-W-relation is also not considered (as in all empirical descriptions of the relation).

Response: It is supposed that what the reviewer mentioned here is that usually the best-fitted curve based on observations is used to represent the Q-W relation, however, the plots of observations may be scattered. If this understanding is wrong, please inform us.

»P. 3814, section 3.2: Why is the reach for determining effective river width not extended to the location of the gauging station? This is not intuitive, so better explain.

Response: The reach between the gauging station and the lower cross-section of the river segment from which the effective width being measured from remote sensing is located in a single river channel with U shape cross-section. The intention of excluding this reach is to increase the variability of the effective width derived from satellite images. The distance between the reach measuring effective width and Pakse station

is only several kilometers. Therefore, we suppose the difference in the amount of discharge is ignorable. In addition, in the paper of Smith et al. (1995, 1996), not extending the reach determining effective width to the gauging station is also used, because the location of gauging stations were out of the spatial extent of the satellite images.

»P. 3818, section 4.2: In the discussion about the estimation of river discharge and the validity of this method, it should be noted, that hydrological models I general have problems in simulation correct flood peak discharges. This has many reasons, like the temporal and spatial resolution of the rainfall input and the model, calibration relative to mean discharges (as implicitly using Nash-Sutcliffe performance), improper representation of hydrological processes, threshold behavior of the water switching to different processes in extreme events, etc.. Considering this and the fact that with the proposed model mostly the flood peaks are not simulated well, the discussion of the validity of the model cold be even more positive. For this purpose, it would also be beneficial to present a model simulation calibrated o the actual discharge time series. Therefore I would like the authors to include such a simulation using the same rainfall input. This doesn't necessarily have to be done be a full GLUE procedure, a “standard” single objective calibration without uncertainty analysis would do.

Response: Thank you very much for this suggestion. The calibration based on daily observed discharge data of 1995-1998 was carried out under GLUE, using the Nash Efficiency as likelihood, and the same 50, 000 parameter sets being randomly generated, with same input forcing data. In the supplement, the simulated discharge by the parameter set that maximize the value of Nash Efficiency(Qq) are shown together with the mean simulated discharge of behavioral parameter sets obtained from calibration based on river width(Qw), and observed discharge at Pakse gauging station(Qobs). Qq stands for the best capability of the rainfall-runoff model for producing the discharge at Pakse. The figure indicates that temporal variation patterns of Qq and Qw are similar. Both can not reproduce the flood peak in 1997 sufficiently. This indicate that the error in Qw for reproducing flood peak in 1997 come from the uncertainty in rainfall-runoff model itself, rather than the shift of calibration objective, which support the statement made by the authors that calibration against river width can not overcome inherent structure error of rainfall-runoff model.

»P. 3819, l. 9-15: please include a figure showing both Q-W-relations to illustrate the difference and note that the regression in Figure 4 is also uncertain. This can be illustrated in a figure showing the relation from the regression with uncertainty bounds and the relation from the "best" model calibration. It would be recommendable to put all this in the present Figure 4, but move it to this section.

Response: Because only 16 river width observations are available, a simple method was used to define the uncertainty bound: moving the relation obtained from regression upwards by one standard derivation (26.35m) of the difference between the satellite observations and values of river width computed from the best fitted curve using corresponding observed discharge as input, the upper boundary is obtained. Similarly, the lower boundary is the best fitted curve minus one standard deviation. The rating curve from the regression with uncertainty bound and the relation obtained from best model calibration will be shown in one figure in the revised paper.

»P. 3820, l. 26-27: Again, here it could be mentioned that the simulation results are not perfect because of the calibration against river widths, but also for other reasons. But therefore the simulation calibrated against discharge needs to be included.

Response: The comparison between simulated discharge by calibration against discharge and river width indicates that, besides the shift of calibration objective, the uncertainty in rainfall-runoff modeling itself also have impact on the accuracy of the simulated discharge. In the revised paper, the two parts will be mentioned clearly when explaining why the simulation obtained from calibration based on river width is not perfect.

Response to the technical issues

»P. 3808, l. 10: "correct" should replaced by "an appropriate", especially when using GLUE for calibration.

Response: The word "correct" will be changed into "an appropriate" in the revised paper.

»P. 3808, l. 14: better write "It can be expressed as" instead of "it is"

Response: "It can be expressed as" will be used in the revised paper.

»P. 3808, l. 24: "river width can be formulated as", in order to indicate that an empirical relationship is used instead of hydrodynamic equations

Response: The sentence will be revised as "Based on at-a-station hydraulic geometry relation, river width can be formulated as follows".

»P. 3811, l. 1: it should read "relative root mean square error". Also, because RMSE is the usual acronym for root mean square error, I would suggest to use another acronym, e.g. rRMSE.

Response: Actually, the likelihood measure being used is the reciprocal of root mean square error (RMSE), not the reciprocal of relative mean square error. It will be corrected in the revised manuscript.

»P. 3818, l. 26: it should read ". . . is valid, the method can be reliable"

Response: The sentence will be revised based on reviewer's suggestion.

»P. 3819, l. 22: please write ". . . proposed method could even be applicable. . . "

Response: The word "even" will be added to the sentence.

»Figures 4,6,7: please add vertical grid lines for better visualization and comparison between figure (6 & 7)

Response: The suggestion will be followed in the revised paper.

»Figures 6 & 7: harmonize the graphical representation of the uncertainty bands for the different likelihood thresholds

Response: The way of expressing uncertainty band in the two figures will be changed into the same style.

»Figure captions 6,7,8: it should read ". . . from parameter sets with associated likelihood values. . . "

Response: The term "with associated likelihood values" will be used in the captions.

»Figure caption 8: please change to ". . . efficiency of simulated discharge for. . . "

Response: The suggestion will be followed in the revised manuscript.

Reference:

Dingman, S.L.: Analytical derivation of at-a-station hydraulic geometry relations, J. Hydrol., 344, 17-27, 2007.

Smith, L. C., Isacks, B. L., Forster, R. R., Bloom, A. L., and Preuss, I.: Estimation of discharge from braided glacial rivers using ERS 1 synthetic aperture radar: First results, Water Resour. Res., 31(5), 1325-1329, 1995.

Smith, L. C., Isacks B. L., Bloom, A. L., and Murray, A. B.: Estimation of discharge from braid rivers using synthetic aperture radar imagery: Potential application to ungauged basins, Water Resour. Res., 32(7), 2021-2034, 1996.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/7/C2192/2010/hessd-7-C2192-2010-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 3803, 2010.