Replies to the comments by referee #1

Dear Editor Albrecht Weerts,

Thank you for sending me the revised manuscript "Calibrating 1D hydrodynamic river models in the absence of cross-sectional geometry [. . .]" by Liguang Jiang et al. for review. The authors have responded to my comments in detail and improved their manuscript accordingly. They suggest easing hydrodynamic model calibration through a reparametrization of the SWE. The authors seem to have experience in model calibration and they demonstrate their method on hand of a suitable dataset. The method is mostly an incremental improvement on existing ones, though the approach contains several interesting details, such as the regularization approach, which will be insightful for the readers of HESS. It is in particular insightful to see that hydrodynamic models can be reliably calibrated with remotely sensed channel-width alone, i.e. without reference depth, which is of importance for modelling ungauged basins.

While I commend the manuscript, its language should be thoroughly revised before publication. I provide an extensive list of suggestions below. It would be considerate when the Danish co-authors supported the first author with that respect before submitting future manuscripts.

Kind regards,

Reviewer

Reply: Thank you very much for taking the efforts to have a careful read and comment on our revised manuscript. Below, we report how we revised the text following your suggestions.

Minor

Structure: I recommend moving subsection 3.3 "Parameter calibration" forward at the end of section 2, as it is part of the methodology.

Reply: Fully agree. We have revised it accordingly.

Appendix A: It is nice to see the parameter relations worked out. It would be insightful to show how the physical parameters are related, and thus could be recovered, from the calibration parameters. For example, $\alpha = \log(w/d0)$, where d0 is a reference depth and $1 < \beta < 2$, which are the limits for a rectangular and triangular cross-sections. Similar simple relations exist for K. This is will be helpful for choosing suitable start values for the optimization and verifying the result.

Reply: At reach scale, the parameters (α, β, γ, and γ) are empirical. Even at-a-station, α and β range from 0 to 2.5 and 1 to 3.5, respectively, for the six rivers we investigated. The values for rectangular and triangular cross-sections do not necessarily stand for the limits. Figure 2 as shown below clearly reveals that the value of β can be larger than 2.

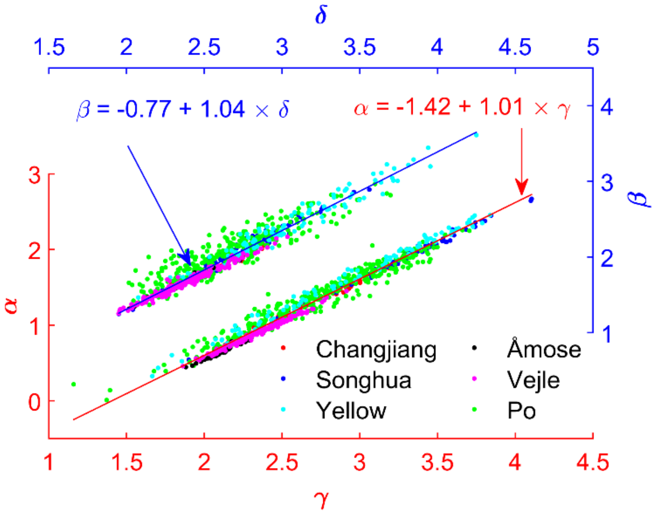

Figure 2. Linear relationship between $\boldsymbol{\alpha}/\boldsymbol{\beta}$ and $\boldsymbol{\gamma}/\boldsymbol{\delta}$. Each dot represents one cross-section of a certain river. Dots of the same color are from the same river. Manning's coefficient for each cross-section is randomly generated between 0.015 and 0.05.

Code and data availability: It would be considerate if the authors made their code publicly available so that others can easily apply the method in their studies.

Reply: Sure, we have made it available on Zenodo (https://zenodo.org/record/5555472). We have noted this in the code and data availability section.

Suggested clarifications

85 "two variables (Q and d) and three parameters (A; S0, and Sf)" → Two variables (Q and d) and three unknown values (A; Sf and S0), which are functions of further parameters as specified below.

Reply: Revised.

95 "K(d) is much more sensitive than A(d)." → The calibration is much more sensitive to K than to A.

Reply: Revised.

150 "parameters [. . .] in addition to bed slope S0 (calculated from Z0)" → "parameters [. . .] in addition to the bed level Z0, from which the bed slope S0 is calculated."

Reply: Revised.

184 Some more information would be insightful here. Are the cross-sections of the hydrological model, or of the validation data? If they are of the model, are the parameters linearly interpolated between the sections? In which interval are the cross-sections placed?

Reply: These cross-sections are used for setting up the hydrodynamic model instead of real-world data. There are in total 23 cross-sections over a span of 433 km as illustrated in Figure 3. Yes, cross-sections are linearly interpolated along chainage in MIKE Hydro River.

To make it clearer, we have revised the text as *"…The first step is to define the river network, cross sections, and boundary conditions. The river network is set up using the center line of the reach,* *while 23 cross sections are equally distributed along the 433 km reach as in Jiang et al. (2019). Daily discharge at Harbin hydrometric station is used as the upstream boundary while a uniform flow depth rating curve is set as downstream boundary …"*

215 Insert the missing sum signs in front of the brackets which are squared.

Reply: Revised.

215 Is the value later reported as RMSE the "misfit" or only the standard deviation between the 10 calibration runs?

Reply: The RMSEs are simply calculated based on model-simulated WSE and in-situ or satellite altimetry derived WSE. And yes, in Figure 5, we calculated the statistics using the 10 calibration runs. This has been added in the caption of Figure 5.

238-243 We use the LM: algorithm [. . .] to optimize the objective function. → We iteratively optimize the objective function (equation. 17) with the Levenberg-Marquardt (LM) algorithm (Marquardt, 1963) combined with Broyden's rank-one update to approximate the Jacobian (Broyden, 1965, Madsen et al. 2004). We use an implementation of the method provided by the Immoptibox toolbox (Nielsen and Völcker, 2010).

Reply: Revised.

Suggested textual improvements

All equations: End with dot or comma, as the equations are part of the sentence.

Reply: Revised.

13 Scarcity/inaccessibility → Scarcity and inaccessibility

Reply: Revised.

14 geometry has commonly been approximated using → geometry is commonly approximated by

Reply: Revised.

15 Simultaneous [. . .] → Some explanation is missing before this sentence. For example: Hydrological model calibration requires both the determination of parameters for roughness and cross-section geometry.

Reply: Revised.

18, 20 power-law functions → power-laws

Reply: Revised.

19 remove "and they are found to be linearly [. . .]", this is already implied by the power-law and thus an unnecessary tautology

Reply: The power-laws are directly applied at each cross-section. The linearity that exists at reach scale is not explicit from the cross-sectional power-laws. We would like to keep this point in the abstract.

30 has been → is

Reply: Revised.

34 different → multiple

Reply: Revised.

36 require detailed → require a detailed

Reply: Revised.

37 by cross-sectional → by a cross-sectional

Reply: Revised.

37 surveyed [. . .] geometry → the surveyed geometry

Reply: Revised.

39 problem facing the scientific community → problem which the scientific community faces

Reply: Revised.

38 used a uniform shape . . .--> used a cross-section geometry which did not vary along the channel.

Reply: Revised.

55 Here → Here,

Reply: Revised.

58 to simulate → for simulating

Reply: Revised.

60 morphology → roughness

Reply: Revised.

61 When calibrating [. . .] → Parameters of channel geometry and roughness are highly correlated during calibration.

Reply: Here we emphasize the simultaneous calibration of geometry parameters and roughness parameters. We think it is better to use the original expression.

63 will be effective, not only representing → effectively represent

Reply: The suggested expression is not informative. We keep our original expression.

64 compensating → compensate

Reply: "not only representing [...] but also compensating" We do not think it is inappropriate.

72 remove "as observations"

Reply: Revised.

80 (2) Sf → Sf (d)

Reply: Revised.

84 is chainage, i.e. the distance → is the distance

Reply: We keep the "chainage" term as it is used later in the text.

85 To effect solution → to solve for

Reply: Revised.

86 bathymetry → the bathymetry

Reply: Revised.

86 Friction slope → The friction slope

Reply: Revised.

98 provide → are

Reply: Revised.

105 power function relationships → power-laws

Reply: Revised.

110 Z → Z0

Reply: Revised.

115 different → several

Reply: Revised.

115 having a wide range of river width (three orders of magnitude). →The width ranges between the rivers over three orders of magnitude.

Reply: Revised.

118 remove "readily"

Reply: Revised.

121 power-law function → power-law

Reply: Revised.

122,123,124 Manning's number → Manning's coefficient

Reply: Revised.

165 and representative of large rivers worldwide. → one of the largest rivers in the world.

Reply: Revised.

169 two rivers merge into one, called Songhua → two tributaries merge to form the Songhua River

Reply: Revised.

170 emptying → draining

Reply: Revised.

171 remove "main"

Reply: Revised.

172 The reason we selected this reach is twofold → The reasons why we selected this reach are twofold:

Reply: Revised.

175 drains → flows

Reply: Revised.

176 at downstream → at the downstream end

Reply: Revised.

183 set → set up

Reply: Revised.

184 Daily → The daily

Reply: Revised.

190 remove "new"

Reply: Revised.

191 entirely different → unique

Reply: We intend to emphasize the “difference” instead of its uniqueness.

195 derived → extracted

Reply: Revised.

196 to avoid → avoiding

Reply: Revised.

230 uncertainty → root mean square error?

Reply: Not necessary. But we can use rmse to represent the uncertainty or error of data.

268 log depth → log Depth

Reply: Revised.

273 small depth → small depths

Reply: Revised.

291 very wide range of RMSE → very large RMSE?

Reply: Here, we mean that the values are very spread instead of very close to each other. We revised as “*the RMSE values of calibrations #2a and #2b are very spread (i.e. a wide range)*”.

297 WSE → the WSE

Reply: Revised.

298 RMSE → The RMSE

Reply: Revised.

381 which is not new [. . .] → which goes back to Chow 1959.

Reply: Revised.

383 and the relationship is generally independent of rivers → and applicable for a wide range of rivers.

Reply: Revised.

385 no explicit consideration of roughness and channel geometry are needed to solve for WSE → the channel geometry and roughness do not have to be explicitly known to determine the WSE.

Reply: Revised.

387 WSE → the WSE

Reply: Revised.

387 remove the qualifier "fairly"

Reply: Revised.

388 By referring [. . .] → Our method performs comparably to existing ones which use conventional parametrization and calibration approaches.

Reply: Revised.

389 this approach → our approach

Reply: Revised.

396 we can get → we get

Reply: Revised.

405 Taking log transformation → Taking the logarithm

Reply: Revised.

405 that leaves → we have

Reply: Revised.

Replies to the comments by referee #2

I appreciate the authors to largely improve the manuscript following my comments/concerns on the previous version. The significance of the proposed work is now explained appropriately, and the comparison to previous methods (Jiang et al 2019) enhance the reliability of the proposed method.

I only have a minor technical comments. In Figure 6, what "Simulation S1" mean is not clear (what S1 stands for? it is explained only in the maintext). I suggest to modify the caption as "(i.e. simultaneous calibration of roughness and cross-sectional shape parameters; S1 simulation in Jiang et al 2019), in order to explain what S1 means.

Reply: Thank you for the positive comments. We have revised the caption according to your suggestion.