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Interactive comment on "Hybrid Neural Network – Variational Data Assimilation algorithm to infer river discharges from SWOT-like data" *by* Kevin Larnier and Jerome Monnier

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This study aims at proposing the hybrid Neural Network (NN) – variation-al data assimilation algorithm to estimate river discharge from simulated SWOT like data. Such methodological studies are very important and of the scope of the NPG. In addition, investigating the potential benefits of satellites prior to the launches is quite useful to improve satellite missions further. However, I think the present manuscript has some fatal issues that should be solved prior to publication. The authors seemed to investigate the method that would not be applicable to the real un-gauged river basins as elaborate below. I am compelled to suggest this manuscript be rejected.

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Discussion paper

[Major Issues] 1. As described, the SWOT-based estimation of river discharge is useful for ungagged or poorly gauged river basins (P1L14). However, the authors used “too rich” basin information. They used dA (difference in cross-section), W (river width), S(slope), and A (cross-section) to estimate Q (discharge) by NN (P8L166).

> Undoubtedly, there is a misunderstanding; moreover there were an error of typing p8l66 ! First, the letter \cal A does not denote the wetted area (hopefully. . .); it denotes the (local) drainage area. The wetted cross-section area is denoted by A. The ANN input variables are (dA,W,S) and \cal A. This was indicated in the abstract, in the introduction (p2l58), p6l135, etc. This was not recalled p8l66; now it is. Moreover, p8l66, an unfortunate copy-paste was present: obviously, the knowledge of dA does not imply the knowledge of A0 ! **

The physical-based models, which were also used to mimic observation data, simulate Q based on dA, W, S, and A with only one major uncertainty parameter: frictions of the river channel. Namely, there is one equation and one uncertain parameter. Solving this problem is too very easy for NN. Consequently, the present experimental setting of NN was very confusing to me. It is usually impossible to use the cross-section A because the cross-section under the river surface is unobservable by satellites. The challenge for realistic applications is to estimate Q without using A.2.

> We agree; if one had considered the observations of A0 (or equivalently of the complete wetted cross-section A), the inverse problem would be much much easier to solve ! Obviously, this is not the case (see above). The considered inverse problem is the most complete and the most challenging one, in the present altimetry context. This inverse problem is those indicated throughout the manuscript eg. in the abstract, in the general introduction and eg. in Section 5. **

The authors assumed unrealistic daily SWOT observation data while real satellite revisits 1-4 times per 21 days (P1L22). Consequently, I strongly suggest the authors re-consider experimental design that is applicable to real problems.

> That is correct, the considered data frequency is 1 day only. This corresponds to the important Cal-Val orbit phase of the satellite.

In short, the considered datasets are synthetic, 1-day repeat, covering a very large rivers sets with very different flow characteristics. This responds to an important science issue, at the forefront of the current Discharge Algorithm Working Group (https://swot.jpl.nasa.gov/documents/4050/)

These points were not sufficiently explained. Now, they are much better indicated throughout the manuscript, including in the new abstract, in the general introduction and conclusion, and of course in the data section too.

Note that if considering the nominal SWOT orbit (which will provide data with 21 days revisit period, depending on the latitude), the scientific challenge which consists to solve the ill-posed inverse problem for ungauged rivers posed by the mission remains the same (see Section 5.3 of the manuscript or our next answer to your comment). In this case, the time validity of the discharge estimation equals the wave travelling time through the river portion (roughly, a few hours to a day, depending on the case), see eg. [Tourian et al. 2017], [Brisset et al 2018], [Larnier et al. 2020] (with the identifiability map concept in particular). This point is well understood now. The present remark has been added in the dedicated new section 3.4 entitled “On the sensitivity of the estimations with respect to error measurements or time frequency”. **

[Other Issues] 1. Experimental design is unclear to me. It is better to add a schematic image that shows the low chart of data used in this algorithm.

> Thank you for this suggestion. We have added in the introduction of Section 5, a figure representing synthetically the complete algorithm (ANN, low complexity algebraic flow model, VDA process based on the St-Venant equations and finally real-time estimations from newly acquired data), the employed data and the priors of the computational method. **

2. The paper should add more hydrological papers for reference. For example, I found a data-driven estimation of river width from satellite data (Yamazaki et al. 2014). Comparisons with such existing approaches would be beneficial to add the values of the manuscript. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013wr014664

> Thank you for mentioning us this reference which aims at “calculating river width from satelliteâĂŘbased water masks and flow direction maps”. This is not the topic of the present study. This study could be an alternative source of the data variable W. For this reason, we mention it now in the data section.

(The aforementioned new version of the manuscript should be posted online within 2-3 working days).

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