Referee comment

General comments

The manuscript presents an interesting and relevant work addressing scientific questions within the scope of HESS. The authors present a successful newly implemented coupled system with the main objective of estimating the outflow from a reservoir in Spain. The methodology developed and applied merges the physical understanding of a physical-based model and the capabilities of artificial neural networks to learn from non-linear processes. Therefore, applying a coupled system highlights the novelty of the work, which is not simply another application of a hydrological model or an artificial neural network to estimate streamflow in a given catchment. In this sense, the authors gave proper credit to related work and clearly indicated their original contribution. The manuscript is well-structured, clear and concise. It is well-written and easy to understand. The authors present a good introduction of state of the art regarding the subject and a well-written description of the study area and the materials ad methods applied. The studies used for introducing the subject and the discussion are relevant and recent. The results presentation and discussion gave a clear and sufficient overview of the results and their respective limitations. The conclusions present an interesting closing of the presented workflow concisely and straightforwardly, but not forgetting to present the future perspectives from this work. Finally, the authors present the workflow code in a public and open repository, contributing significantly to open science and making it possible the work reproducibility. Therefore, the paper deserves to be published in HESS after some corrections and adaptations regarding the guality of the writing and figures.

Specific comments

In this section, I present some specific comments to be answered and implemented in the manuscript. No changes in the methodology are proposed, only suggestions for the writing, discussion and overall figures and tables quality.

- 1. The authors provided a complete public repository with the workflow. I recommend not going into too much detail within the text regarding the specific Python libraries and functions applied in this methodology.
- 2. Likewise, regarding the MOHID-Land model, since the model was already implemented in the referenced work of Oliveira et al. (2020) where it was fully described, the information regarding the implementation not already presented in this work should be given in the present details in Annex instead of in the main text. The authors can consider only a summary of the information instead of being in such details in the present work.
- 3. The authors conclude that the poor representation of reservoir levels reflects the non-inclusion of evaporative losses in the model (L529). I agree, but do the authors have concrete results corroborating this? Did you perform tests including it in your model? Would that be a possibility for further work? For this work, it is optional to make this inclusion. However, more evidence could improve your conclusions.
- 4. I would like to have a deeper discussion about why, even with the limitation in reproducing the reservoir levels, the model still performed well in reproducing the streamflow at the outlet. Is this due somehow to the concentration time of the watershed? A slight increase in the discussion will enrich your paper.
- 5. L361: What would cause this behavior by the model in your option? Could it be further discussed in the text?
- 6. L452: In this part of the discussion, the authors claim several limitations to using the CLSTM model. The text follows, describing several concerns, but are those the limitations intended by the authors to be mentioned here? I recommend rewriting this part text for clarification.
- L459-461: The authors claim that the optimization of the CLSTM could improve the results. Why
 was this not tested for this work? I would appreciate a further discussion of this matter in the
 manuscript text.

Technical corrections

In this section, I present some technical corrections and suggestions to be implemented in the text. This section is divided into an initial general part and later divided by each text section (e.g., Abstract, Introduction).

General:

Please refer to the guidelines template available at (<u>https://www.hydrology-and-earth-system-sciences.net/submission.html#templates</u>) when reviewing your manuscript.

Symbols and variables:

Consider a full check in all the symbols, such as "m", "Km" etc., to ensure they are correctly placed near their respective words. Consider using a standard number of decimals in nearby sentences, e.g., "11.6 and 2.5m", and not "11.6 and 2.55m".

Equations and variables:

For all equations, please make sure to cite them in the text before presenting them using the HESS guidelines for equations, i.e., using the label "Eq. (X)" or "Equation (X)" depending on the situation. It is a better practice to refer to your equation as:"...using Eq. (X):" instead of solely mention "...using the equation below:". Additionally, Make sure to have all variables in italics when mentioned in the full text, e.g., x_{scaled} and not x_{scaled} .

Figures and tables:

Please consider improving the figures and tables' quality regarding font size, style and colors. The figures should have a similar style, and the authors can think of improving their quality following some suggestions in the further sections. Please ensure that all figures and tables located in the main text are mentioned in the text. Finally, please move some tables and figures to the annexes and reduce the final number of figures in the manuscript's main text by merging them when possible.

Abstract

L10: Re-word from "estimate" to "estimation".

L12: Please present the main objective of the manuscript more clearly. Beginning the presentation of your objective in the abstract with: "In this study, and already implemented..." does not capture the main objective of this study which is the development and application of a coupled system. Please start your objective presentation by making sure to present this information. Make sure to have your abstract following this pathway: Contextualization/Relevance – Objective – Methodology – Results – Conclusions.

L13: Please consider deleting the part: "..., calibrated, and validated solution of..."

L18: Re-word from "This coupled system was daily evaluated in two hydrometric stations..." to "This coupled system was evaluated on a daily basis using two hydrometric stations...".

L22: Consider changing "modified rivers" to "modified catchments".

1 Introduction

L24-28: Consider to summarize this list of activities and situations.

L31: Delete "mechanisms". It was already mentioned and it is redundant. Forcing is enough.

L37: Re-word from "makes it impeditive" to "poses a challenge".

L42: Delete the extra space after "faced".

L54-56: Consider using numbering to list those two tests, i.e., "(a) first the weir was simulated as static (with closed sluice) to identify the sluice 55 operating rules by comparing results with the known outflow time series; (b) second the weir model was run as non-static to implement the sluice operating rules deducted from the first approach."

L56: Consider start a new paragraph after the previous mentioned statements.

L76: I believe that if you keep using "the physical-based..." you should refer the official MOHID-Land reference, and not the previous work. However, if you re-word to "a physical based distributed Mohid-Land..." you may keep the reference to your previous work.

L80: Consider moving "However, the CLSTM model was first trained and tested using historical data." to L78, after you introduced the CLSTM model.

2 Materials and methods

2.1 Description of the study area

L90: Consider re-word from: "-0.75m" to "-1m". Is it not necessary to be so precise at this description.

L92: Insert a reference for the Köppeb-Geiger classification.

L102: Clarify what you mean by "set of reservoirs". The other two reservoirs? Or the whole set?

L104: Consider to use a synonym for "however" since it was already mentioned nearby.

Figure 1: Consider inserting the "Atlantic ocean" and "Mediterranean sea" labels on the figure. The palette choice for the countries is not colorblind friendly (consider alternative colors for green and red together). It is also a little difficult to identify the reservoirs in the figure. Consider altering the font sizes with their respective names, or moving these labels. Re-word "water bodies/lines" to "water courses". Re-word "Basin delineation" to "Ulla river watershed" for clarity. Check the legend color bar labels. Are those correct? Finally, it is missing the latitude and longitude or X and Y coordinates of the study area. They should be inserted in the map.

Figure 2: You have four subplots here. I would consider two changes: (1) subplots a-c should have the same Y-scale, e.g., 0-450 m³s⁻¹. Subplot d can keep its scale since it refers to a different time-period.

2.2 MOHID-Land description & 2.2.1 Reservoirs module

As this work uses the already implemented model from Oliveira *et al.* (2020), I would consider a summarization of these sections, and if needed the addition of this full description in Annex. This description is interesting to understand the MOHID-Land implementation; however, it is too long for this section and for the scope of the present work. In Annex, you can additionally insert more details (if needed).

2.2.2 Model set-up

L166: Re-word from "...not influenced..." to "...not directly influenced..."

As a suggestion, you may also summarize this paragraph (not as much as the previous two) and insert some more descriptive information in Annex.

Table 1: Consider moving this table to Annex.

Figure 3: Consider moving this figure to Annex.

Table 2: Consider moving this table to Annex.

Reservoirs set-up

Table 3: Consider moving this table to Annex. Additionally, consider inserting the minimum and maximum volume, and the minimum outflow values inside Figure 4. Hence, this information would be kept in the main text even though the insertion of the table in annex.

Figure 4: Change the title to "Level *versus* stored volume curves for (a) Portodemouros, (b) Bandariz, and (c) Touro reservoirs." Include the numbering (a), (b) and (c) outside the figure at the right upper part, as it was in Figure 2.

L211: Delete the sentence "and by default".

2.3 Neural network model for reservoir outflow estimation

L217-218: Delete "...(convolutional neural network, long short-term memory, multi-layer perceptron, extreme learning machine, etc.)"

L234-236: Consider the use of a connector for the beginning of the paragraph (e.g., additionally) and rephrase the sentence to a non-passive voice.

L234-240: Consider rephrasing this paragraph for clarification.

2.3.1 Input data

L242: Delete: "selected from a set that included".

2.3.2 Structure

L255: Delete "based".

L256-257: Delete: "As referred before, a CLSTM model is based on convolutional and long short-term memory layers."

Figure 5: Change the title to "CLSTM structure used in this work". Please consider showing also the variables in this scheme, or the possibility of merging this figure with Figure 6.

L262: Insert "the" before "convolutional layers", i.e., "For the convolutional layers..."

L265: Please consider rephrasing to: "...The loss was estimated using the mean absolute error (MAE). Finally, the number of epochs and the batch size were respectively 300 and 20, found after a trial and error procedure."

2.3.3 Model optimization

L270-272: Please consider to do not be so descriptive about the packages and delete these sentences: "The training dataset was handled and prepared with Pandas (McKinney, 2010) and Scikit-learn Pedregosa et al., 2011) packages, with the data being delayed with the first and scaled with the latter."

L272: Rephrase to: "The data was scaled using Eq. 1 to each variable independently."

L275-277: Change the variables to the italic format in the text.

2.4 Coupling MOHID-Land and CLSTM models

L294-296: Rewrite the sentence using a non-passive voice.

L300: "...used to stabilize the hydrological model," was already mentioned before.

L303-304: Re-word from "This model" to "The calibrated model". Add the plural in "level" and "inflow".

L307: Delete: "This scheme was coded in the Python language.".

Figure 6: As mentioned before, please consider the possibility of merging this figure with Figure 5.

2.5 Model's evaluation

The text in this section must be re-organized for clarity. The content is all there, but the sentences seem out of order, confusing and repetitive. Please consider the following structure: (a) first you give the initial idea (as done), (b) then you present and discuss the validation period; (c) then you present and discuss the test period; (d) finally you explain the metrics used. The metrics were used for both periods; therefore, it would sound better if they were mentioned after or before the two periods, and not between them.

L314: Re-word from "analysis" to "inspection"; and "namely" to ",i.e.,".

L316: Re-phrase to: "...which were computed using Eqs 2-5 respectively."

L323: Insert a new paragraph at "The test dataset..."

L330: Consider the new work from Moriasi as an updated reference: Moriasi DN, Gitau MW, Pai N, Daggupati P (2015) Hydrologic and water quality models: Performance measures and evaluation criteria. Trans ASABE (am Soc Agric Biol Eng) 58(6):1763–1785. https://doi.org/10.13031/trans.58.10715

L330: Correct from "R2" to "R2".

3 Results

3.1 MOHID-Land model

I would suggest the authors to consider mentioning Figure 7 on section 3.3 instead that at this section.

Table 4: Please consider the insertion of a new column referring to the location of the station, i.e., upstream of downstream the reservoirs.

L341: After ending the discussion about the Sar, Ulla, Arnego-Ulla and Deza hydrometric stations, please consider opening a small description of the results from Table 4 for Ulla-Touro and Ulla-Theo. Please ensure to mention in the text the potential causes of the low-performance.

Figure 7: Besides moving this figure to section 3.3, please consider adjusting the y-axis range of the two subplots to the same scale. I suggest both to "0-600". It is always better for a visual comparison from the readers. Move the labels "a" and "b" to the upper left outside of the subplots area.

3.2 CLSTM model

Table 5: Add a row with the chosen set of statistical variables. You have the average, minimum, maximum, and standard deviation, but an additional row with the chosen set would be useful.

L355: Delete "always".

L359: Consider to add for clarification: "...outflow using observed levels and inflows as forcing."

L364: You observed May and June 2016 in Figure 8. Can this period be highlighted in the figure?

Figure 8: Please consider rephrasing the title to "Comparison between modelled and observed Portodemouros outflow considering the CLSTM model."

3.3 Coupled system

Figures 8 and 9: Please consider to merge those two figures in a single one.

Figure 9: Change the title to "Comparison between the modelled and observed (a) inflow and (b) outflow in Portodemouros reservoir using the coupled model."

Figure 10: Please consider moving this figure to the discussion section.

L395: Delete: "It could be expected that this issue would affect streamflow estimation downstream the reservoir since the outflow estimated by CLSTM model considered the level values estimated by MOHID-Land." Please consider deleting this phrase and keeping just the last sentence.

3.4 Impact of reservoirs 'operation on streamflow

L403-404: Rephrase to "with reservoirs (Res.)" and "without reservoirs (No res.)". The abbreviation should be placed after the words.

4 Discussion

L451-454: The sentence: "With the choice of the forcing variables being pointed out by several authors as crucial for a successful model (ASCE, 1996; Maier et al., 2010; Dolling and Varas, 2002; Wu et al., 2014; Juan et al., 2017), the consideration of other forcing variables should be evaluated." Seems disconnect from the previous sentence. Please consider rephrasing it.

L487: Did you mean by "environmentally friendly streamflow" the "environmental/ecological flow"? If yes, please rephrase it.

5 Conclusion

L529: As you did not do the test I would consider changing this word from "...in part..." to "...probably...".

L529: Consider the inclusion of: "... on the performance of the coupled system in the computation of daily streamflow...".

References:

Oliveira, A. R., Ramos, T. B., Simionesei, L., Pinto, L., and Neves, R.: Sensitivity Analysis of the MOHID-Land Hydrological Model: A Case Study of the Ulla River Basin. Water, 12(11), 3258, https://doi.org/10.3390/w12113258, 2020.

Moriasi DN, Gitau MW, Pai N, Daggupati P (2015) Hydrologic and water quality models: Performance measures and evaluation criteria. Trans ASABE (am Soc Agric Biol Eng) 58(6):1763–1785. https://doi.org/10.13031/trans.58.10715