Dear Editor and Reviewers,

We appreciate your time and effort handling and reviewing our manuscript. Thank you for your thoughtful comments, which have been very helpful in improving the manuscript. In the following, we have addressed each comment of the two reviewers in blue text. The text added in the revision is shown in italics in this response.

Response to RC1

The manuscript proposed new hydrological parameterization for ELM in the Lower Mississippi river basin by constraining ELM predicted water table depth with predictions from a calibrated 3D subsurface hydrology model. Then the manuscript conducted simulations during the period of Hurricane Ida using both default and new parameterization with ELM and compared the simulated hydrological and nitrogen responses to Ida with observations. The study concludes runoff process is important to predict hydrological and nutrient responses to heavy rainfall events.

Overall, the paper is easy to read. However, One thing is unclear to me - what is the key evidence that calibrated ELM is better than default ELM? It seems to me the biggest difference is that default model does not predict changes in WTD but calibrated model predicted shallower WTD after Ida. The conclusion states that "the calibrated ELM was able to simulate the increased nitrate-nitrogen runoff leaching during Hurricane Ida" (Line 472-473) but both versions predict increases in runoff and N Loss (Fig. 5e and Fig. 6a) and it is not discussed which one is closer to the observation. Given this is a model evaluation paper, more direct and quantitative model-data comparison would be helpful

Thanks, we are glad the reviewer found our manuscript easy to read. Below are our point-by- point responses to your comments.

One thing is unclear to me - what is the key evidence that calibrated ELM is better than default ELM? It seems to me the biggest difference is that default model does not predict changes in WTD but calibrated model predicted shallower WTD after Ida.

We apologize for the oversight in not including the uncalibrated results. As can be seen from the figure below, the uncalibrated model resulted in WTD ranging between 3 and 5 m and performs poorly in simulating the spatial distribution of WTD when compared to Tran2024.

We added this statement in Section 3.1 in the revision for clarification:

When running the uncalibrated ELM, the simulated WTD ranged between 3 and 5 m, with an R^2 value of -1.66 when compared to Tran2024, indicating poor performance in simulating the spatial variations of WTD.

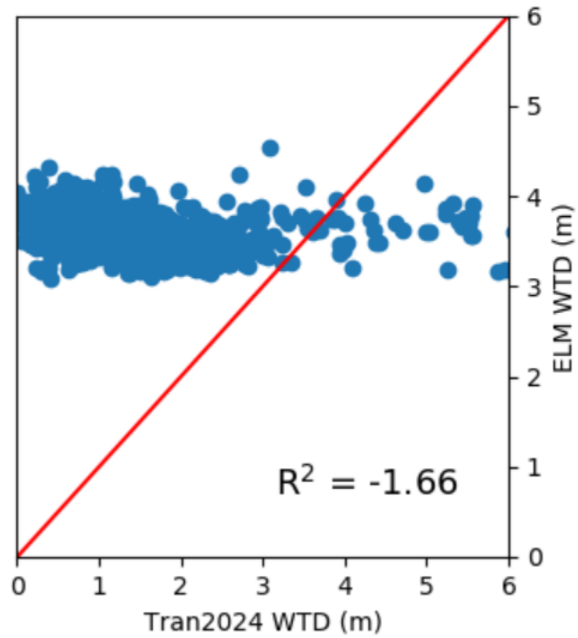


Figure R1. Simulated water table depth using the default uncalibrated ELM, compared to Tran2024 in year 2015.

Some additional comments:

Line 195-205. The whole training workflow reads a little confusing to me. WTD is a model ouptut depending on fmax and fdrai but it is used to predict fmax and fdrai... Doesn't it make more sense to create a model/emulator for WTD based on ELM inputs and parameters and then find the best fmax/fdrai to get WTD values close to Tran2024 WTD?

We agree that running multiple ELM simulations with varied f_{max} and f_{drai} parameter values to train an emulator which can then be used to find the optimal value could be an effective method for closely matching the observed WTD values from Tran2024. To produce training data for the emulator requires a large ensemble of simulations with perturbed parameters, which can be computationally expensive. Instead, we opted for the iterative approach described in Section 2.4. This method allowed us to efficiently calibrate the parameters. We have added the following justification to the revised manuscript.

The parameter estimation can be achieved by running multiple ELM simulations with varied f_{max} and f_{drai} parameter values to train an emulator that can be used to find the optimal parameter *values. While this could be an effective method for closely matching the observed WTD values from Tran2024, it needs a substantial number of simulations to produce the training data, which can be computationally expensive. Instead, we explored an alternative approach by using machine learning.*

Line 285. For nitrogen and runoff loading response, it seems only one station has significant response but the other one (07381600) did not? Any explanations? In addition, is the model able to explain the decline of Nitrogen and Runoff Loading before Ida?

Thanks for this comment. As described in line 170 in the original submission, station 07381600 is a near shore station, which has more influence from the ocean as can be seen from the river stage in Figure 2b.

Unfortunately, the model cannot be used to explain the decline of Nitrogen and Runoff loading before Ida. The primary focus of our study was to investigate the hurricane's effect on runoff nitrogen loading. Simulating the entire dynamics of nitrogen within the stream requires in-stream N transport and obtaining data on detailed N utilization in the area, which is beyond the scope of this study. To address the comment, we acknowledged this limitation in the revised manuscript at the end of section 4.2 and highlighted that future model developments could be used to explain such dynamics.

Note that the current version of the ELM does not include an in-stream nitrogen model, which is under active development. Consequently, while our study successfully examines the impact of hurricanes on runoff nitrogen loading, it does not fully capture the complete dynamics of nitrogen in stream before and after the hurricane, and hence it cannot be used to explain the observed N loading dynamics before Ida. Future improvements to the ELM, including the integration of an in-stream N model, will enable more detailed and accurate simulations of nitrogen and runoff loading dynamics in rivers.

Line 370. Fig. 6 panel a, if the value is cumulative sum, the unit should just be gN/m2 without per month.

Thanks for catching the error. We removed "per month" in the figure.

Line 410. There is not panel g in Fig. 8

Thanks for the careful review! We have corrected to caption as

Figure 8. Heatmap comparison of soil moisture and soil mineral nitrate-nitrogen between the default model (a,c), the calibrated model (b,d), subsurface runoff (e) and nitrogen leaching loss (f) at a selected nearshore grid.

Line 432-433. What are the "valuable insights"?

We have revised this sentence for clarity:

This suggests ELM can provide some valuable insights into the mechanisms driving nitrogen runoff loading during hurricanes, such as the significant role of surface runoff and changes in water table depth.

Response to RC2

The Manuscript developes a new soil hydrology parameterization for ELM for the Lower Mississipi River Basin (LMRB) in an effort to better understand nitrate loss. This proposed calibrated model predicts water table depth from a 3D subsurface hydrology model. The authors then conducted simulations of the Hurricane Ida of period and compares default ELM and calibrated model simulated results with observations.

I think the manuscript is relatively easy to read and understand and proposes a novel way to improve our understanding of nitrate leaching. However, I struggle to understand which model performs better in the context of the observations. Both versions predict an increase nitrate runoff but having these comparisons with direct observations on the figure would help the reader understand how model performance compared.

We thank you for your kind and encouraging words and your recognition of our novel approach to improving the understanding of nitrate leaching.

The primary focus of our study was to investigate the hurricane's effect on runoff nitrogen loading. Unfortunately, we were not able to use the model for direct comparison with observations as the model cannot simulate in-stream N transport. We acknowledged this limitation in the revised manuscript at the end of section 4.2 and highlighted that future model developments could be used to explain such dynamics.

Note that the current version of the ELM does not include an in-stream nitrogen model, which is under active development. Consequently, while our study successfully examines the impact of hurricanes on runoff nitrogen loading, it does not fully capture the complete dynamics of nitrogen in stream before and after the hurricane, and hence it cannot be used to explain the observed N loading dynamics before Ida. Future improvements to the ELM, including the integration of an in-stream N model, will enable more detailed and accurate simulations of nitrogen and runoff loading dynamics in rivers.

Additional comments

Figure 1 make the USGS points larger to improve clarity

Increased the size of the USGS points. Thanks!

In figure 3f, I understand the overprediction but why are there a bunch of points at just less than 4m?

Thanks for the observation and question. These are probably points that cannot obtain an optimal solution simply by tuning two model parameters.

Comparing the WTD of figure 5C to observations in 4A was difficult and model results and observations seem very different.

Thanks for the comment. We didn't intend to use the model to compare with observations as it requires additional data and model development, which is beyond the scope of this study. We added this sentence in the Introduction for clarification:

We will not delve into the full dynamics of nitrogen cycling within the stream due to the limitation of the model, as addressing the limitation is beyond the scope of this study.

line 232 Specify what exactly those insight are

Thanks for the comment! We assumed you meant line 432 in the original submission. We added further details for clarification in the revised manuscript, which is repeated below:

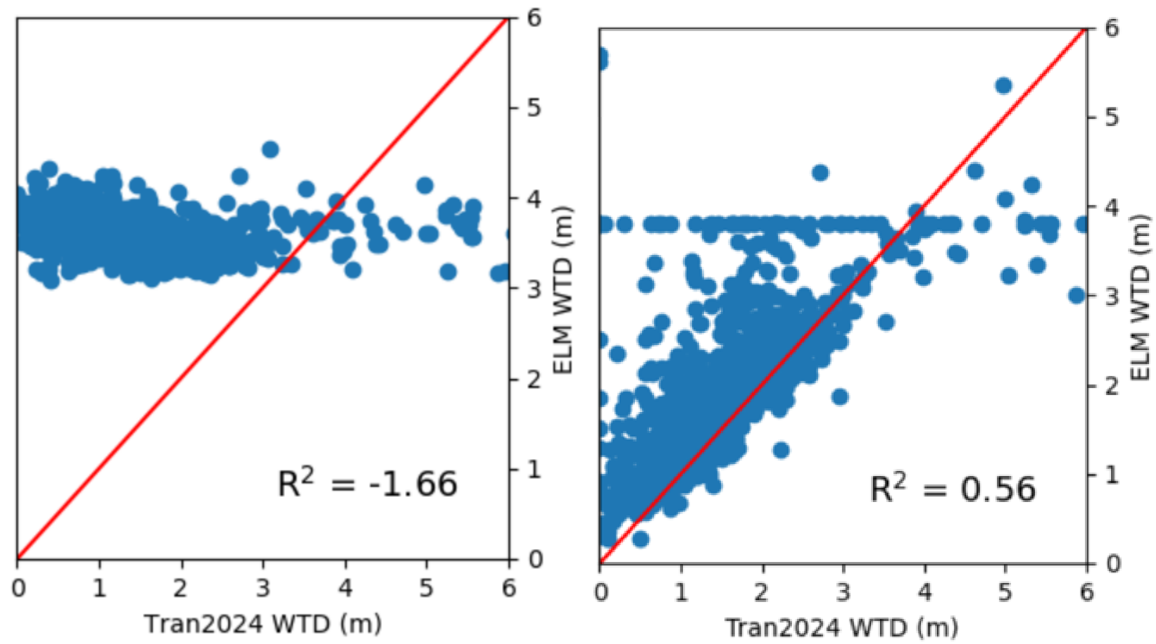
This suggests ELM can provide some valuable insights into the mechanisms driving nitrogen runoff loading during hurricanes, such as the significant role of surface runoff and changes in water table depth.

Line 382 Cod"e"

Thanks! Corrected to "Code".

The biggest issue with the paper was understanding whether the default model or the calibrated model performed better.

The calibrated model performs better in WTD as can be seen from the figures for the default model (left panel) and calibrated model (right panel). The model itself was not used to quantitatively compare the N loading from model simulations with the observations for the reason provided in our response to your main comments.



R2 = -1.66
R2 = 0.56
Tran2024 WTD (m)
Tran2024 WTD (m)
ELM WTD (m)
ELM WTD (m)
0
1
2
3
4
5
6