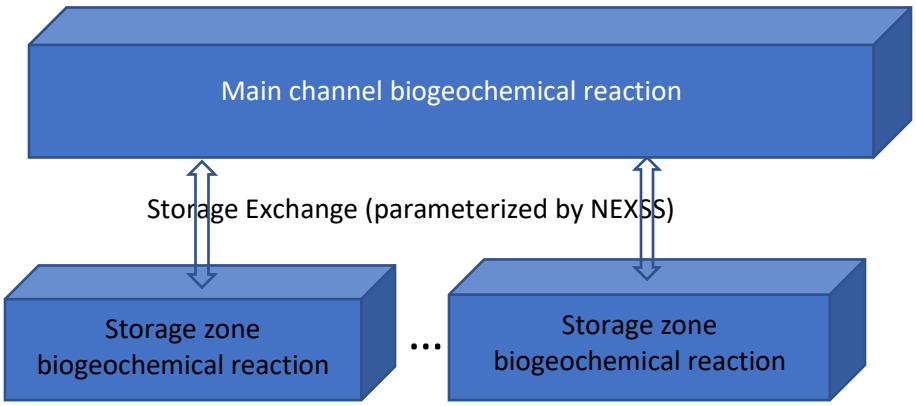
Anonymous Referee #1

The discussion paper "A multirate mass transfer model to represent the interaction of multicomponent biogeochemical processes between surface water and hyporheic zones (SWAT-MRMT-R 1.0)" introduces a newly-developed model, named SWATMRMT-R, to simulate the hydrological and biogeochemical interaction between surface water and hyporheic zones. Hyporheic zone is usually ignored in large-scale watershed models because of its complex processes. Therefore, I think adding the simulation of hyporheic zone processes and connection hyporheic zones and surface water has a good intention and is appreciated. I have some major comments for this manuscript:

Response: We thank the reviewer for acknowledging the value of our model and the encouragements.

1.The manuscript description about SWAT-MRMT-R, the connection between SWAT and MRMT, the connection of SWAT code and PFLOTRAN is not very clear. There is abundance of model concepts, software, and codes involving in this work (SWAT, MRMT, PFLOTRAN, NEXSS, NHD plus V2), and the connection between them was mentioned in different places in the manuscript. But I want to put in in a figure/schematization, to make the readers clear about the role of each of them in the model. I recommend modifying figure 1 or having a separate figure showing the connection between these.

Response: We only modified the in-stream nutrient transformation module in SWAT for the purpose of this study. The stream water column and a hyporheic zone at a reach in a river network can be conceptualized as separate batch reactors gaining or losing mass due to hydrologic exchange. NEXSS is only a tool used to estimate the hydrologic exchange fluxes and residence times for discretized reaches for a river network (NHD plus V2 in this study). The results from NEXSS were provided to us from our collaborator, and we used them as input to the model developed in this study. NEXSS is not required as long as there is a way or model to estimate the hydrologic exchange fluxes and residence times. The following schematics shows the connections between different reactors. The storage zones do not communicate with each other. The reactions within these batch reactors and mass transfer between the in-stream reactor and hyporheic (storage) reactors are solved using PFLOTRAN.



2. It is not very clear to me about the connection in hydrology between SWAT and MRMT. Does SWAT provide inflow of upland catchment to hyporheic zones which is represented by MRMT, and how the transmission losses through streambed calculated by SWAT affect the hyporheic zones? I think hydrological exchange between surface water and hyporheic zones is very important for the constituent exchange, so please make it clear.

Response: We agree that the hydrological exchange between surface water and hyporheic zones is very important for the constituent. MRMT is an extension of the commonly used transient storage model to represent riverine solute transport. It does not affect the hydrology part of SWAT. As SWAT solves solute transport and reactions using the operator splitting approach, we only modified the in-stream nutrient transformation module in SWAT for the purpose of this study, treating the hydrological exchange between the storage zone and stream as kinetic process or "kinetic reactions".

3. How many storage zones in your conceptualization of the hyporheic zones? Is the number of storage zones defined by the user in the setup? What is the maximum number of storage zones?

Response: The model is not limited by the number of hyporheic zones. The number of storage zones can be defined by the user in the setup.

4. Why can NEXSS not use the reach system generated by SWAT to calculate residence time and exchange flux?

Response: NEXSS can use different reach system as long as the values of bankfull channel width, discharge, median grain size, channel slope, sinuosity, and regional hydraulic head gradient along and across the reach are prescribed for each individual reach. We only used the NEXSS output from a previously generated model based on NHD river network through our collaborator and it is not our focus in this study.

5. For matching the channel systems between NEXSS and SWAT, it seems that NEXSS reaches that do not overlap with those of SWAT are not considered. In the example in figure 2b, only reaches 386 and 380 contribute to SWAT reach 36. However, I think reach 374 also contributes to SWAT reach 36. If we change the threshold stream definition in SWAT, SWAT can generate a more detailed stream network and can overlap with all of the reaches from NEXSS.

Response: In the current configuration, NEXSS reaches that do not overlap with those of SWAT are not considered. We agree that a more detailed stream network can overlap with all of the reaches from NEXSS.

6. The paper shows several modelling experiments. But I wonder if the authors did compare the model predictions with field measurements. I did not see calibration/validation in this paper. I do think the comparison with measurements is very necessary for a modelling paper. So please add a session on this if data is available.

Response: We agree that the comparison with field measurements is necessary. We didn't compare with field measurements in this study as we don't have available data. But the comparison is planned when we have observations from field campaigns, which are ongoing.

7. Do you have a SWAT model application in this case study? Do you consider comparing SWAT-MRMT-R with SWAT to show the better prediction when hyporheic processes are included?

Response: We don't have model application yet. But it is planned for future study when field data are available. One of the advantages of the model is that it can be used to define the reaches that are biogeochemical hot spots in space before conducting the experiment and then combine the model with experiment data collected at those hot spots for a better mechanistic process understanding of river corridor functioning at the reach scale.

8. SWAT-MODFLOW coupling SWAT and MODFLOW models can represent hyporheic zones and its interaction with the stream. The author should add reference about SWAT-MODFLOW in the manuscript. What is the advantage of SWAT-MRMT-R compared to SWAT-MODFLOW? I suggest adding a section discussing about the strengths, weakness/limitations of the models, what cases the users should use SWAT-MRMT-R in the manuscript.

Response: We agree that a fully integrated model such as SWAT-MODFLOW can represent hyporheic zones, but it is computationally demanding when high resolution simulations are needed to capture the hyporheic zones that are highly variable in space and time. SWAT-MRMT-R we developed in this study is a simplified model that is easy to be adapted and is useful in providing insightful predictions of controls on time and locations of biogeochemical hot spots and river corridor functioning using physically derived parameters at the reach and watershed scales.