Response to Anonymous Referee #3:

Dear Referee #3,

Thank you very much for your helpful comments and suggestions to improve our manuscript. To facilitate this discussion, we first retype your comments in **bold font** and then present our responses in blue to the comments.

This paper introduces a novel approach to study the effects of surface and subsurface water regulation on dissolved organic carbon (DOC) transport. The authors combine a DOC model with the CLM/MOSART model to simulate the DOC dynamics in both surface water and groundwater systems. This is an innovative contribution because most previous studies and models have neglected the role of water extraction in DOC dynamics and the interaction between DOC and groundwater. However, the paper needs to improve in several aspects before it can be accepted. First, the paper does not clearly quantify the relationship between DOC concentration and water flux in different processes. For instance, how much DOC is removed by surface water and groundwater extraction? Second, the paper does not present the model results in an effective way. Some maps have poorly designed color bars and do not show the spatial patterns clearly. Since the main focus of the paper is on DOC export, some results are not relevant and should be moved to the supplementary information.

Response: We appreciate your clear and detailed feedback, and hope that the response has fully addressed all your concerns. In addition, our model incorporated DOC dynamics schemes to CLM and RTM (River Transport Model) instead of MOSART.

Page 2

Line 30:

Rivers are a pipe linking the two major carbon pools of terrestrial and ocean ecosystems.

Maybe "aquatic ecosystems"? Since the river also connects to the lake, etc.

Response: Thanks for your comment. Rivers indeed connect other inland aquatic systems such as lakes, but here we want to express that rivers link two major carbon pools: the land and the ocean.

Line 31:

IPCC AR5, full name if it is the first-time usage

Response: We will revise it.

Line 34:

"This", what this is referred to?

Response: This means that the annual DOC transported from terrestrial ecosystems to the ocean via rivers is equivalent to about 1% of the global NPP of terrestrial ecosystems.

Line 35-37:

Higher than what? Consider breaking this long sentence to shorter ones.

Response: Thanks for your comment. It means riverine DOC is a rather highly reactive organic carbon. And we will revise it as you suggest.

Line 45

May define DOC leaching before use? Also, consider breaking this sentence into shorter ones.

Response: Thanks for your comment, we will revise it.

Line 61:

There are at least some time series DOC measurements in some datasets, even if they are not long-term measurements.

Response: Thank you so much for your careful check. We will revise this sentence to "Moreover, only annual averages are usually available, with no long-term time series variation."

Line 90:

Why not use the same resolution, such as 0.5 degrees, for land and river?

Response: Due to the limitation of available computing resources, the spatial resolution of the model was fixed to 0.9º × 1.25º for land, and 0.5º × 0.5º for river. Besides, since river module is typically run at a finer resolution than land, the land variables are interpolated to the river grid by coupler in the model.

Line 103:

What do you mean by linear RTM? More details are needed.

Response: CLM5.0 includes two river routing methods: RTM and MOSART. RTM is a linear reservoir method, which uses a linear transport scheme to route water from each grid cell to its downstream neighboring grid cell.

Line 124:

What are upstream and downstream, can you link these processes in Figure 1 so readers can understand what Equation 1 is illustrating in Figure 1?

Response: Please refer to Lines 113-118. The transformation cascade is shown in Fig.S1. And transfers of carbon from upstream to downstream pools in the decomposition cascade are given as:

$$CF_{Lit1,SOM1} = CF_{Lit1}(1 - rf_{Lit1})$$

$$CF_{Lit2,SOM2} = CF_{Lit2}\,(1 - rf_{Lit2})$$

$$\dots$$

$$CF_{SOM2,SOM3} = CF_{SOM2}\,(1 - rf_{SOM2})$$

For more details please see CHAPTER 21 of the CLM5.0 technical notes (Lawrence et al., 2018).

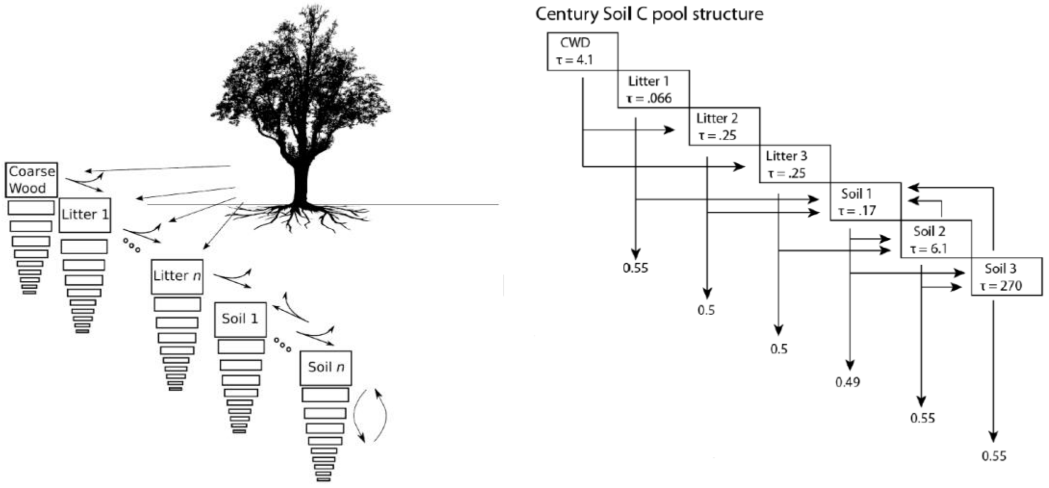

Figure S1: Schematic of decomposition model (Century model) in CLM. Pool structure, transitions, respired fractions (numbers at end of arrows, rf), and turnover times (numbers in boxes).

Line 132:

The unit of DOC is inconsistent from Line 127. Normally, DOC concentration is expressed as mg C / L. Based on Equation 3, [DOC] is unitless.

Again in Line 139, you used another unit for [DOC] as mg g soil-1.

Please unify the DOC units.

Since you mentioned both adsorption and desorption, you should describe both processes and their equations.

Response: Thanks for your comment.

(1) The unit of [DOC] in our developed model is **g C kgH2O^{-1}**, which is calculated by dividing NS_{DOC} (g C m^{-2}) by WS_{tot_soil} (kgH_2O m^{-2}). In fact, kgH2O is equivalent to L, but in different expressions.

(2) In calculating the sorption coefficient of soil DOC, the concentration unit is normally **mg g soil^{-1}**, thus we made a unit conversion during the model calculations.

(3) We have described the adsorption and desorption processes. Please refer to Lines 134-140. In Eq. (5), RE is the amount of DOC desorbed (negative value) or adsorbed (positive value), calculated by the simple initial mass (IM) linear isotherm.

Line 153:

I assume that Equation (7) DOC_leached is the LDOC? If so, you can make them the same.

How about RDOC? How is it modeled?

Response: Thanks for your comment. In this study, R_{DOC} is defined as the soil DOC in surface runoff, while L_{DOC} refers to subsurface losses of DOC in soil water. And we will modify it as you suggest.

Line 188:

How are these coefficients obtained? Please provide some details or references.

Response: Thanks for your comment. We will add the reference in our manuscript.

Besides, how sw and gw are linked to DOC? For example, if there is SW extraction, then shouldn't it be included in Equation (8), such as a term to describe DOC extraction?

Response: Equation (8) is just the riverine DOC transport framework. Please see Sec. 2.5 for more information on how anthropogenic water regulation activities affect DOC transport.

Line 214:

The land component is not 1 degree by 1 degree, so there is some inconsistency.

Response: In the land surface model, $0.9^{\circ} \times 1.25^{\circ}$ is usually considered as 1 degree grid resolution.

Line 220:

Is it ok to have spatial interplate dam/reservoir data? Maybe more details are needed to show how it was conducted.

Response: Thanks for your comment, we will add a figure about spatial distribution of reservoir data in the supplementary.

Line 245:

Use scientific notation for large numbers.

Response: We will revise it.

Line 247:

Which was generally consistent? If they are consistent, then it should be "which is consistent". There is no need to use the past sense.

There are a few hotspots in the high latitudes, where they are permafrost regions, why are DOC losses relatively higher there?

Response: Thanks for your advice, we will revise this sentence. Besides, due to the large amount of soil organic carbon stored in the permafrost zone. With global warming, the melting of the soil layer in the permafrost zone will be accompanied by the release of organic carbon, especially DOC (Li et al., 2019).

Line 252:

How about a time series evaluation? For example, the DOC concentration at a large river outlet?

Response: Due to the few datasets of long time-series observations of DOC fluxes for large global rivers, we only use the annual datasets to validate the model simulations. In the future, we will collect more observations for time series evaluation.

Line 254:

What do you mean by overestimated or underestimated? Compared with what?

In Figure 3d, the color represents both magnitude and over/underestimate. This can be confusing. Since you have a color bar, readers will assume the color represents values based on the color bar.

Response: It is the result of comparing the simulated value with the observed value; if the simulated value is higher than the observed value it is an overestimate and the opposite is an underestimate. In addition, we will add a legend to the figure as you suggest.

Line 260:

This simulation is already a global-scale DOC export study.

Response: Yes, we want to express that our developed model is reasonable.

Figure 4

The positive/negative of latent heat/sensible heat need to be checked. Also, the color bar should match the actual ranges.

I am not sure why a multi-year temperature average is needed. If surface water regulation has an impact, then maybe comparing the differences with or without regulation is more meaningful.

Soil moisture cannot be negative, so the color bar needs revision.

The same applies to runoff.

Response: Figure 4 shows the difference in surface hydrological variables between EXPA and CTL, indicating the effect of surface water regulation, so there exist negative values. In addition, We will revise the title of the figure to make it easier for the reader to understand.

Figure 7, what is the reference of the change?

Response: In Fig. 7, the blue line is the difference between EXPA and CTL, indicating the effect of surface water regulation; the orange line is the difference between EXPB and EXPA, indicating the effect of groundwater regulation.

References:

Lawrence, D., Fisher, R., and Koven, C.: Technical Description of version 5.0 of the Community Land Model (CLM), NCAR, NCAR, Boulder, US, 2018.

Li, M., Peng, C., Zhou, X., Yang, Y., Guo, Y., Shi, G., and Zhu, Q.: Modeling Global Riverine DOC Flux Dynamics From 1951 to 2015, J. Adv. Model. Earth Syst., 11, 514–530, https://doi.org/10.1029/2018MS001363, 2019.

Once again, thank you very much for your comments and suggestions.

Sincerely,

Yanbin You, Zhenghui Xie, Binghao Jia, et al.