Response to Reviewer 2

We thank the reviewer for his/her time dedicated to this manuscript. We found the comments highly valuable to improve the quality of our manuscript.

Please see our detailed replies to each comment in blue. Text in bold is text that is copied from the new manuscript. Text in bold and highlighted in yellow is new text added as a result of the review.

General Comments

This manuscript describes the new floodplain scheme implemented in ORCHIDEE model, evaluates the validity of the new scheme, and analyzes its impact on other land surface variables. Even though it's still a case study simulation over Pantanal, I feel the paper very carefully analyzed how floodplain is important for land surface modeling.

The modeling strategy seems to be a bit complicated, while I feel the complexity is necessary given that the floodplain inundation itself is a complex physical process. I suggest the authors to provide more kind explanations about floodplain parameterization scheme, for example by using schematic figures, to help readers to understand how the proposed floodplain scheme works. However, the manuscript is overall well written, while minor revision is needed before acceptance.

Major concerns

[1] I feel the manuscript is too long. It might be unavoidable as a model description paper, but readability might increase if not-so-important parts are moved to supplements.

We agree with your comment, there has been an important effort of reducing the text and of moving figures into the supplement section before submitting the initial version. We kept this issue in mind when integrated the changes related to the reviewers' comments.

[2] So many variables/symbols are used to parameterize the proposed floodplain scheme, and I feel difficulty following the explanations and equations. I suggest creating one schematic figure which represents the parameterization concept of floodplain scheme (with explicit description of which symbols correspond to which variables). Visual explanation must help readers to understand about the new floodplain scheme.

Your comment is totally relevant, most of the variables were present in Figure 1, however the name of fluxes and reservoirs in this figure did not correspond anymore with the text. We decided to update this figure harmonizing the name of the variables with the names used in the equation and adding the variables that were not present, such as Evapotranspiration and Precipitation over floodplains and infiltration from floodplains.

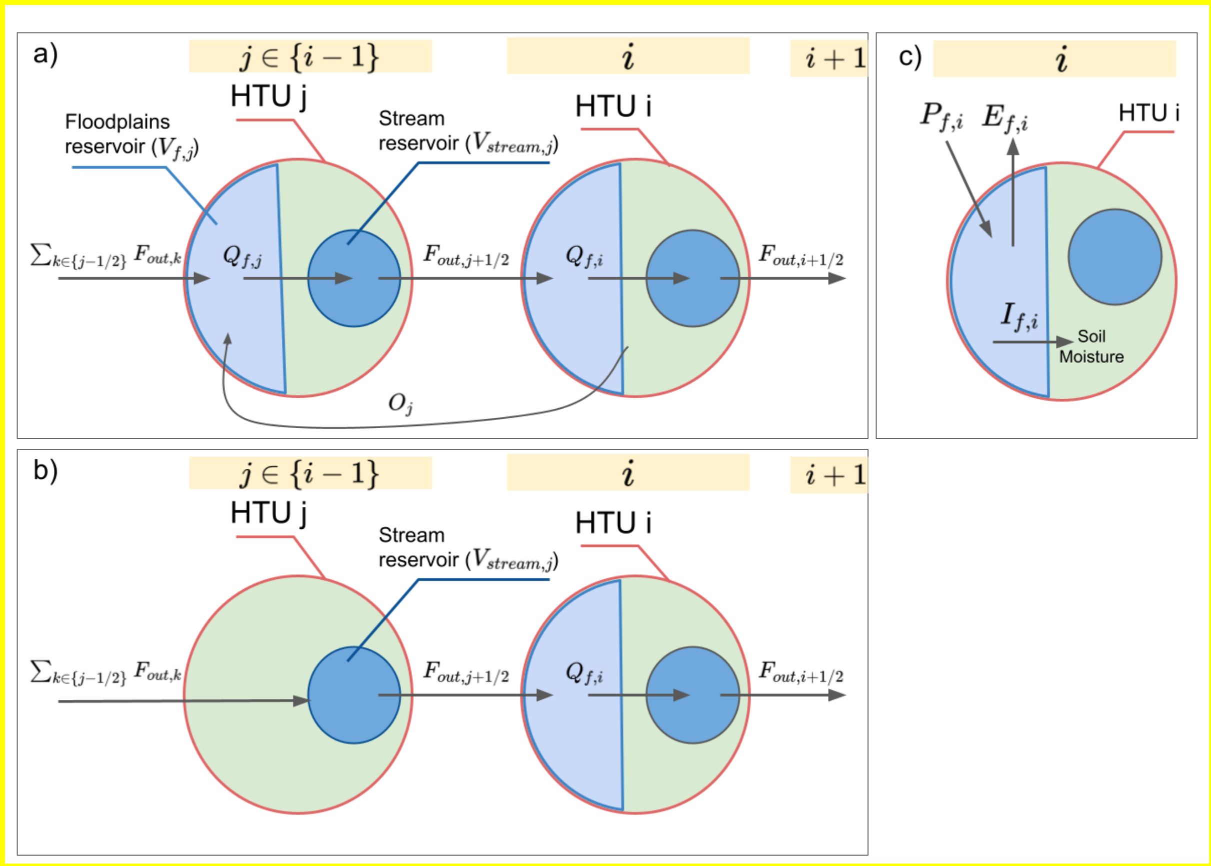

Figure 1: Scheme summarizing the movement between the different reservoirs for a HTU which has floodplains and its upstream HTUs if (a) the upstream HTU has floodplains or if (b) the upstream HTU doesn't have floodplains and (c) the fluxes between the HTU, the atmosphere and the soil moisture.

Specific comments:

L193: whether the floodplains are activated or not.

This should be "regardless of whether …"

Thank you, the text has been corrected.

In addition, please explain what slow and fast reservoir represent. It is explained in the results section that they represent aquifer and shallow groundwater, but this should be stated here. Otherwise, readers cannot know why they have limited relationships to floodplain scheme.

We agree with your comment, we have changed the description to add these details:

Each HTU contains four water reservoirs used by the river routing scheme to represent processes with different time constants: the stream reservoir for the river flow processes, the fast reservoir receiving the surface runoff, the slow reservoir which receives the deep

drainage and the floodplain reservoir. The fast and slow reservoirs can be viewed respectively as a conceptual representation of the rapid shallow aquifer and the slower deeper one.

L235: The floodplains scheme allows a specific HTU to "overflow" the content of its floodplains reservoir into connected upstream HTUs with floodplains.

This is a very interesting scheme. I wonder what is the impact of this overflow scheme on simulated water and energy budgets. If space allows, please include some analysis.

The energy and water balance are performed at the level of the grid cell, therefore it is difficult to assess the impact of the overflow. The impact that can be distinguished is for the overflow, transporting water from a HTU in a grid cell to another HTU in another grid cell.

The best option to perform this analysis would have been to perform an additional simulation without overflow to compare it. This can be an interesting experiment in future studies with the floodplains scheme. However, we haven't performed such an experiment and the content of the paper is already very dense.

We also have thought to track the fluxes of overflow, but this was technically impossible because this would have represented a very large amount of data because this would have been saved in the HTU grid (even the discharge is not saved at the HTU level we only save it for a limited number of stations).

L284 2.4.1: Case S_f,I < S_fmax,i

I recommend you to explain the case in plain language in the section title, not by the equation.

Thank you for this comment, we changed the title to more explicit version of them:
Cases of not fully flooded floodplains

Cases of fully flooded floodplains

L285: height of the floodplain

This term is ambiguous. Do you mean "water surface elevation of the floodplain"?

You are right, we changed the formulation.

L331: in order to define a mask of potentially flooded areas based on the following categories:
Could you please explain in which case this floodplain mask is required, and what is the impact of using this floodplain mask?

The floodplains mask is required when there is a process of flooding, mainly driven by overflow of a river.

The objective of the floodplains is to identify the regions which are susceptible to flood due to the presence of a river. Among the existing categories, the one which better fit is the "freshwater marsh, floodplain". We also decided to include the reservoir to capture the existing flooded existing along the Paraná river and which flood is driven by the river.

L355: before using the scheme over another region to evaluate if this parameterization is the more appropriate.

In many parts of the world, there is no observation data for calibration. If possible, it's better to perform some sensitivity tests of parameters (confirm results are not so sensitive to parameters, or specify which parameter has larger impact).

We agree with your comment, we reformulated the subsection about calibration to clarify the sensitivity of the different parameters.

The different parameters of the floodplains scheme have been calibrated based on the simulated discharge at the *Porto Murtinho* station, which is the reference station at the outflow of the Pantanal (Brazil, lat: 21.7°S, lon: 57.9°W) between 1991 and 1996 in comparison to the observations considering: (1) the variation of the discharge through its correlation with the observations and (2) the mean value and variability of the discharge. The choice of the 6 years calibration period was due to a limited number of available years from the simulations (24 years). Therefore, the model has been calibrated over this reduced period common to both forcing in order that the results analyzed after are not influenced by an overfitting effect. Considering that our model have a reduced number of physical variables, we consider it is not necessary to assess it on large periods as we made the assumption that these parameters are relatively independent of the hydrological cycle variability. However, we agree that performing the calibration over a larger period of time could have been preferable, but we faced 2 limitations for this point: 1) the period of the simulations (AmSud was only available from 1990 to 2019) and 2) a technical limit due to the resources (time and computational resources) needed to run the simulations.

The parameter with the largest influence on the variability of the discharge is τ_f, the time constant of the floodplains reservoir. This parameter has an important impact on the annual cycle of the discharge at Porto Murtinho station. The $[\alpha_{stream}, \alpha_{fast}]$ interval is considered as a valid interval for τ_f. This interval has been discretized to select different possible values for τ_f.
It has been assessed along with R_{limit} which is the second parameter with the largest influence on the discharge. For R_{limit}, we discretized the [0,1] interval to obtain possible values.
In a first step, these two parameters have been calibrated together, we performed a grid-search evaluation, which means that we evaluated all the existing combination of possible discretized values over the intervals for τ_f and τ_f to select the combination with the best performance to represent the observed discharge.

In a second step, we assessed the parameters related to the overflow, which have a limited impact on the discharge OF and OF_{repeat}. These parameters slightly

influence the temporality of the discharge. In this case, we also assessed these two parameters using a grid-search evaluation considering a discretization of the following intervals: [0.5 day, 2 days] for OF and [1 repetition, 5 repetitions] for OF_{repeat}.

Finally, the last parameter to calibrate is the infiltration constant (C) which determines the loss to soil moisture and, thus, potentially to evaporation. This parameter with a very reduced impact on the discharge and only reduce / increase the level of the discharge at the outflow of the region. We discretized the [0,1] interval to assess it.

L360: Methodology of Validation and Analysis

Please also provide some description of the simulation domain. Probably, a figure showing the simulation domain (with location of the gauges) is better to be provided.

Thank you for your suggestion, we agree that this should be included, the following Figure I has been added in Annex.

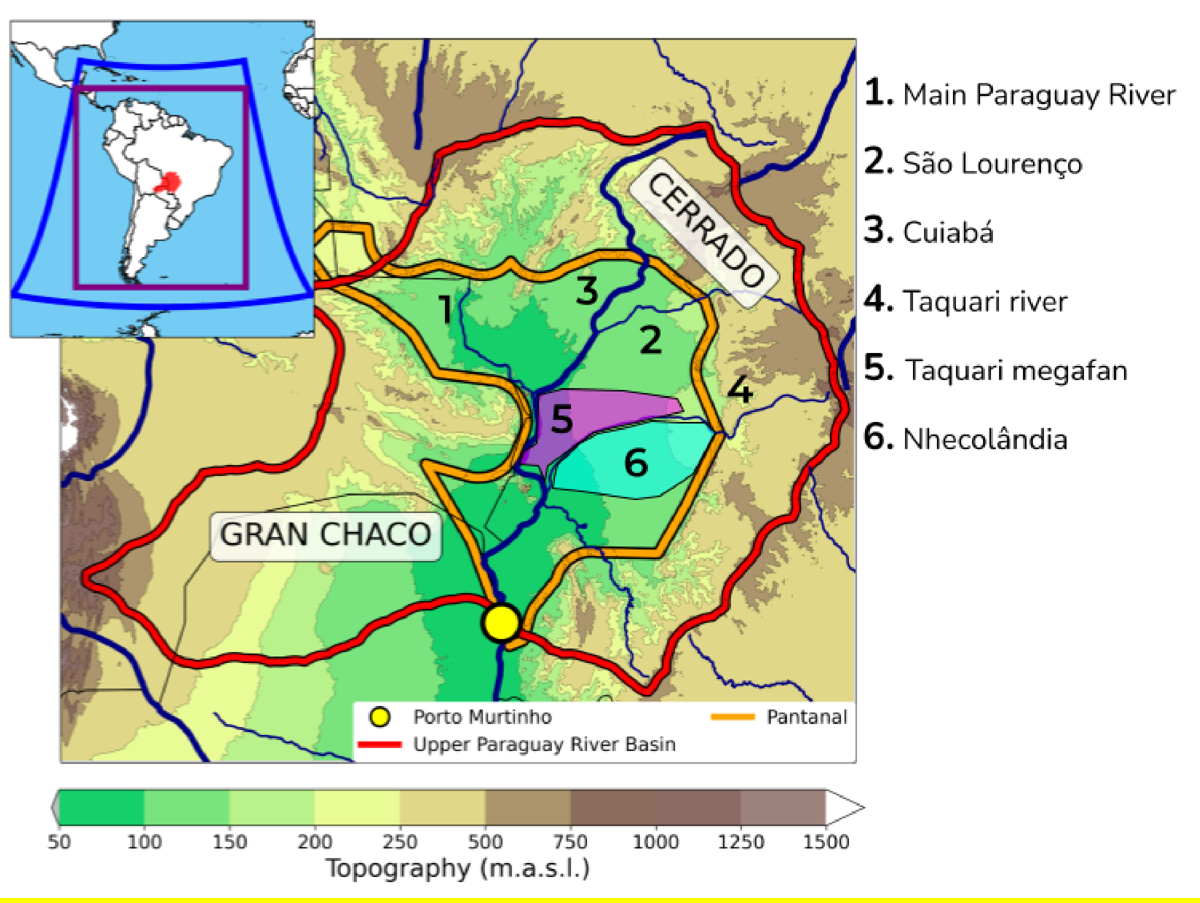

Figure I: Description of the domain used for both simulations (AmSud_GPCC and WFDEI_GPCC) as well as the description of the Upper Paraguay River Basin region with delimitation of the Pantanal. The different rivers, regions and hydrological stations mentioned in the present articles are also described

L419: forced with ERA5 re-analysis data.

I assume this is regional atmospheric simulation, and in that case ERA5 must be “boundary condition” rather than “forcing”.

You are right, this has been clarified.

Figure 2:
Could you please analyze the mechanics of river discharge delay? E.g. where water stays before reaching to the river gauge? Did they stay in floodplain as surface water? Or did they stay in soil by infiltration? Given that the difference between FP and NOFP simulation is large, it’s better to provide detailed analysis on the mechanism which cause the difference.

Thank you for your comment, we specified the following in the analysis:

The main mechanism behind the river discharge delay is that the water is delayed in the floodplain reservoir. Another part of the delay is also related to the infiltration of the water in the floodplains into the soil, which face a larger delay. Then, the evapotranspiration also plays an important role as it will reduce the mean annual river discharge.

L507: soil moisture and in the stream reservoir increases slightly

Considering the magnitude of change, compared to other storage variables, I feel the soil moisture was “significantly” increased by floodplain scheme (it’s not slight increase).

Thank you for your comment, we agree that it is not the right term as the increase is strong compared to volume of water in other reservoirs. This has been corrected.

L508: This increase is even more important in the fast and slow reservoirs.

Please also reconsider this statement. The relative increase could be large, but absolute change is larger in soil moisture.

We think that your comment is relevant, we changed the text accordingly.

Figure 3:

I suggest it’s better to make some discussion on the water volume change and annual river discharge (by converting annual discharge to volume unit). How large the volumetric change in each reservoir is, compared to the annual discharge? This analysis must be essential to understand why discharge seasonality changed significantly.

Thank you for your comment, we added the discharge in Figure 3 as a reference.

L551: divergent flows which very sensitive to the orography and cannot be represented in this model

Please explain why divergent flow cannot be represented. (i.e. because only one downstream is assumed for the model's river network).

Thank you for your comment, we added this precision.

[...] which is an area of divergent flows which very sensitive to the orography and cannot be represented in this model (Louzada et al., 2020; Assine, 2005) because the model's river network is convergent and only assumes a downstream.

L639: vegetation fraction decrease

I think vegetation fraction can decrease also due to water logging along floodplains (too much water). It seems this impact is not considered in the proposed model, so better to be mentioned as a limitation.

You are right, vegetation can also decrease due to water logging along floodplains, however this is not included in the model. We provided an overview of the mechanisms not considered by the river flooding scheme in the description of the model (Section 2):

The floodplains scheme does not include divergent flows, neither groundwater lateral flow. Also, it does not include the reduction of the vegetation due to water logging along floodplains.

L816: . The divergent processes are not represented in the Hydrological DEM and, therefore, are not implemented in ORCHIDEE.

Divergent flow is represented in MGB-IPH and CaMa-Flood by analyzing high-resolution topography data (Pontes et al. 2017; Yamazaki et al 2014). Given that representation is possible, I think it's better to mention about the possibility.

You are right, there are some models integrating this possibility, we corrected this part by adding that there are divergent models and quoted some examples.

The divergent processes are not represented in the Hydrological DEM and, therefore, are not implemented in ORCHIDEE. However, some models such as MGB-IPH and CaMa-Flood represent this divergent process by analyzing high resolution topography data (Pontes et al. 2017; Yamazaki et al 2014).

L860: IMaps

What is IMaps? Please explain.

Thank you for highlighting this mistakes, it is replaced by "**Spatial description of wetlands**".

Bibliography

Pontes, P. R. M., Fan, F. M., Fleischmann, A. S., de Paiva, R. C. D., Buarque, D. C., Siqueira, V. A., Jardim, P. F., Sorribas, M. V., and Collischonn, W.: MGB-IPH model for hydrological and hydraulic simulation of large floodplain river systems coupled with open source GIS, Environmental Modelling and Software, 94, 1–20, https://doi.org/10.1016/j.envsoft.2017.03.029, 2017

Yamazaki, D., Sato, T., Kanae, S., Hirabayashi, Y., & Bates, P. D. (2014). Regional flood dynamics in a bifurcating mega delta simulated in a global river model. Geophysical Research Letters, 41(9), 3127-3135.