## Responses to Anonymous Referee #1

Below are our point-by-point responses to the comments of Referee #1.

General comments: *In this contribution, Pereira and co-authors propose an update to the surface water structure of the Ecosystem Demography (ED2) model, throughout the implementation of a river routing scheme. The model was successfully applied in the Tapajós River Basin, a major tributary of the Amazon River. In general, the approach for model calibration/validation is standard and demonstrated a significant improvement between observed and simulated river discharge. In my opinion, although the results are easy to understand, the manuscript requires substantial scientific structuring and improvement if it is to be considered further. The model development itself is not a compelling motivation without a clear scientific question in the background. The paper should advance understanding of hydrological processes and report novel findings. Moreover, the discussion should be closely linked to the recent literature on topics related to large-scale (i) river routing model developments and (ii) inland waters importance. I included specific and technical comments in a separated PDF file as to improve this interesting paper.*

Please also note the supplement to this comment: http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-114/hess-2016-114-RC1- supplement.pdf

Response: We thank the referee for his/her thoughts and extensive feedback on the manuscript. We wish to emphasize that this manuscript is not a research article, but rather a technical note. As described on the HESS website (http://www.hydrology-and-earth-system-sciences.net/about/manuscript_types.html): *"Technical notes report new developments, significant advances, and novel aspects of experimental and theoretical methods and techniques which are relevant for scientific investigations within the journal scope"*. Specifically, the purpose of this technical note is to describe and evaluate an integrated framework for capturing the variability of streamflow as a response of changes in land surface and climate change. It is not a new hydrological model, but rather strategic integration of an existing land surface model (ED2) with an existing hydrologic routing scheme (derived from MGB) suitable exploring the combined effects of climate and land cover change on patterns of river flow static land cover of the traditional hydrological models).

This integrated modeling framework was developed to explore the following research questions: (1) How do current and simulated climate and/or future forest cover affect water scarcity in closed-basin systems? (2) How can forest-dependent changes influence the water availability in large reservoirs? (3) What are the implications of those changes in the land use policy? In line with the referee's comment, we will revise the manuscript's introduction to clearly articulate the kinds of research questions that motivate the development of this new modeling framework.

Regarding the referee's comment that *"the discussion should be closely linked to*

*the recent literature on topics related to large-scale (i) river routing model developments and (ii) inland waters importance"*, we agree that some recent studies were overlooked in the discussion. As per the referee's suggestion, we will revise the discussion section to place the manuscript's findings in the context of recent research on river routing modeling developments and the importance of inland waters.

Supplement Comments:

1. Pg 1 L1: Text and language notes: "*Avoid the repetition of the same idea in the different parts of the text and the excessive use of adjectives (i.e. substantial, serious, unique, substantially, etc.)"*

Response: As per the referee's suggestion, we will revise the text in order to avoid repetition of ideas and curb the excessive use of adjectives.

- *Although, in general, the english is clear, consider final text edits by a native english.*

Response: The manuscript's senior author is native English speaker and the manuscript was also proofread by another native English speaker. The revised manuscript will be closely proof-read before resubmission.

2. Pg 1 L22: *This sentence is background...*

Response: As suggested, this sentence will be deleted.

3. Pg 2 L1: *Actually, the study showed that the river routing method improved the model river representation, when compared to a 'no river representation'...Isn't it obvious, or not?.*

Response: We believe that the statement "the integration of ED2 with the lateral routing scheme substantially improves the ability of the model to reproduce daily to decadal river flow dynamics …" is relevant because terrestrial biosphere models, which are being widely applied to examine the impacts of climate and land-use on the hydrology of the land surface, are typically "no river representation" models. While the referee is not surprised by the improved ability of ED2+R to predict patterns of runoff compared to ED2, in our opinion demonstrating and quantifying the extent of the improvement is important for justifying the need to develop integrated modeling frameworks such as ED2+R. In line with the referee's suggestion, we will revise the sentence to include quantitative metric(s) regarding the magnitude of the improvement in flow predictions following incorporation of a horizontal routing scheme.

*Also, river routing methods exists in a long time. why is this result important, specially, when compared to other existing models, as you cited.*

Response: as noted above, the purpose of this technical note is not the development of a river routing scheme, but rather the integration of a terrestrial biosphere model with a hydrological model. Although river routing schemes have widely been employed in

hydrological models, in this technical note we incorporate a river routing scheme into a terrestrial biosphere model. The most important aspect of this paper is the incorporation of terrestrial ecosystem responses to climate, carbon dioxide, and land-use change as simulated by terrestrial biosphere models with hydrologic modeling. Incorporating these features improves the representation of the hydrological characteristics in basins characterized by large forest cover and/or high deforestation rate. In the revised manuscript we will stress the significance and novelty of this integrated modeling framework and the practical applications of this approach.

4. Pg 2 L8: Highlighted word: *"serious"*

Response: We were unclear about what the referee is asking for here.

5. Pg 2 L11-12: Deleted Text: *"(i.e., evapotranspiration, soil moisture, deep percolation, surface and sub-surface runoff)"*

Response: The requested text will be deleted and the sentence revised in line with the referee's suggestion.

6. Pg 2 L15-17: Deleted Text: *"Terrestrial biosphere models can mechanistically represent the multiple interactions among land-surface energy balance, the hydrological cycle, and the carbon cycle that occur in terrestrial ecosystems". "You can finish the first paragraph with the following... Examples.."*

Response: This sentence will be shortened as per the referee's suggestion.

7. Pg 2 L23: *This study focus on river routing... too much background information about the evolution of the vertical balance formulations, specially, when compared to literature of recent advances on large-scale river routing. Improve this aspect. For instance, see Cama-Flood from Yamazaki et al. 2011 and other developments since then. I suggest your introduction should convey the idea of why river routing modeling is important and/or needed? Yazamaki et al. 2011 Water Resour. Res. 47, W04501, doi:10.1029/2010WR009726*

Response: A detailed description of the terrestrial biosphere model and its assumptions was requested by the Editor following the initial submission of the manuscript. However, we agree with the referee that recent advances on large-scale river routing are also relevant and can introduce further details about river routing in the revised manuscript, explicitly answering the question of why river routing modeling is important and needed, including the suggested Yazamaki et al. (2011) paper.

8. Pg 3 L1-5: Deleted Text: *"In this way, terrestrial biosphere models can estimate the temporal and spatial distribution of water resources across the simulated domain under changing climate and land cover conditions. The accurate computation of the vertical water balance, however, is only part of the process of estimation of river flows, which are vital data for water resource management (e.g. flood control, hydropower, irrigation)." You already talked about global issues in the first paragraph. I suggest you go further with the*

*global scale issues.. focus...*

Response: As suggested, the above two sentences will be removed from the manuscript. Regarding the comment suggesting "we go further with global scale issues", we will revise the sentence to provide further details about the kinds of analyses that can be conducted by integrating terrestrial biosphere models with river routing schemes.

9. Pg 3 L6-7: *This sentence "that could be compared with actual river gauge observations.." is weak. Despite "matching" modeled and observed data is needed during model development (i.e. calibration/validation) this is a weak motivation. You are developing a process-based model... of course you want a good performance, but why? Describe your motivation in this perspective.*

Response: In line with the referee's suggestion, the sentence will be revised to better express the practical implications and motivations for incorporating a routing scheme. While the ability to evaluate the terrestrial biosphere model's predictions of runoff has value, we agree with the referee that the primary motivation is to conduct studies on the impacts of climate change and land-use on river flow that are useful and relevant for water managers and policy makers.

10. Pg 3 L10: *There is a good opportunity to improve the description of the river routing models used in these studies. This is important to situate the ED2+R approach in the "state-of-art" here and further in discussion section. What was your motivation to use Muskingum-Cunge routing scheme in and not other?*

Response: We opted for the Muskingum-Cunge method as the routing scheme in our modeling framework because this is an approach that has been well adopted for regional scale hydrological models like MGB, VIC, or SWAT, thus providing us the confidence that the flow routing scheme used would provide us computations comparable to these "state-of-the-art" watershed models. We will revise the paragraph to improve the description of other routing models used in other studies and to explain our choice of the Muskingum-Cunge method for ED2+R.

11. Pg 3 L15-23: *This paragraph has too many details and background on ED2. Also, there is too much emphasizes on model capabilities, which are not specially relevant in this study. For instance, I've found "ideally-suited" and "unique tool" and "successfully" .. this is too much.*

Response: As noted earlier (see response to comment 7 above), details and background about ED2 were requested by the Editor. The adjectives describing the model's capabilities are supported by the results of the studies cited in the manuscript and were designed to highlight the some of the capabilities of the ED2 terrestrial biosphere model. We will revise the sentence to describe these capabilities in a more plain matter-of-fact manner.

12. Pg 3 L17-20: Deleted Text: *"One of the key benefits of ED2's formal approach to scaling vegetation dynamics is its ability to describe, in a physically*

*consistent manner, the coupled water, carbon and energy dynamics of heterogeneous landscapes (Hurtt et al. 2013; Medvigy et al. 2009; Moorcroft et al. 2001).”* “This second sentence repeats the overall idea of the first sentence...”

Response: in the revised paper, the two sentences will be merged as suggested.

13. Pg 3 L20-23: Deleted Text*: “ED2’s ability to incorporate sub-grid scale ecosystem heterogeneity arising from land-use change means that the model is ideally suited for investigating of how the combined impacts of changes in climate, atmospheric carbon dioxide concentrations, and land-cover are affecting terrestrial ecosystems.” excessive details and model 'capabilities'*

Response: please see our response comment #11

14. Page 3 L24-29: *This is interesting, but what was this studies findings? How could a river routing scheme in ED2 fill any scientific gaps concerning this past studies? Did any these studies indicate the need for a river routing method?*

Response: the cited studies (Hurtt et al. 2002; Albani et al. 2006; Zhang et al. 2015; Knox et al. 2015; Swann et al. 2015) were not aimed at assessing hydrological implications of deforestation/climate change. Our study brings an additional capability to the range of scientific questions that have been investigated with the ED2 model. Specifically, the integration of ED2 with the Muskingum-Cunge river routing scheme provides a way to understand how historical changes and future projections of the impacts of climate change and deforestation may affect the Amazon’s water resources. In addition, it is a first step towards a full two-way coupling of the routing scheme and ED2 that is likely to improve the ability to reproduce the hydrology of flooded ecosystems, a feature for simulation of Amazon tropical forest ecosystems, many of which experience significant seasonal inundation. These two points are already noted in the discussion section (see page 9, lines 29-32 of the manuscript) and in the concluding remarks (see page 10, lines 17-22 of the manuscript).

15. Pg 3 L29-31: Deleted text: *“ED2 is a unique tool to evaluate impacts from global and regional changes on ecosystem function, and therefore, it could provide critical information for hydrological studies.”*

Response: We will revise the sentence to better highlight the value of integrating a river routing scheme into ED2 . Please see comments #7 and #11.

16. Pg 3 L32-33: *At the moment, the introduction indicates you implemented river routing mostly because ED2 didn't do it.. and that it could be useful.. ok..*

*Your scientific question is not clear.. based on background literature. Why are you doing this study? Again, why do you want to improve the river routing?Why inland waters are important?*
*One reason: Cole et al. 2007 Ecosystems (2007) 10: 171–184*
*DOI:10.1007/s10021-006-9013-8*

*Why modeling and remote sensing are needed at large-scale? Some examples..*

*Alsdorf, D. E., E. Rodríguez, and D. P. Lettenmaier (2007), Measuring surface water from space, Rev. Geophys., 45, RG2002, doi:10.1029/2006RG000197.*

*Prigent et al. (2007) Global inundation dynamics inferred from multiple satellite observations, 1993–2000, J. Geophys. Res., 112, D12107, doi:10.1029/2006JD007847.*

Response: As per comment 15 above, we will revise the sentence to better highlight the value of integrating a river routing scheme into ED2, including the citations mentioned by the referee.

17. Pg 4 L1: *How do you know this? Can you show this?*

Response: the point here is to highlight that our approach incorporates detailed land surface dynamics of the biosphere model into the hydrological analysis. Traditional hydrological models do not represent the dynamics of vegetation, which have very important implications for regional hydrological cycles. However, we are not proposing a comparison between the ED2+R and traditional hydrological models.

18. Pg 4 L5: *Why the interest in Tapajos? And why in Tapajós only.*

Response: The integrated ED2+R framework was developed as part of a research initiative examining how environmental change could affect the future of Brazil's electricity planning. The analysis focuses on the Tapajós river basin because it is planned to be home to a major portion of the planned hydropower expansion. In the revised paper, we will add a more detailed description of the reasons why we are interested in the Tapajós.

19. Pg 4 L9-12: *This paragraph is huge. Again, too much details on model structure and abilities.*

Response: please see comment #11. As suggested, the paragraph will be shortened in the revised manuscript.

20. Pg 4 L12-14: Deleted text: *"The resulting", "then", "a formal", "that accurately captures the resulting" to reproduce...*

Response: in the revised paper, this sentence will be modified as suggested.

21. Pg 4 L18-22: Deleted text: *"Generally, plant functional types are represented by: early successional trees (fast growing, low wood density, and water needy); mid-successional trees; late-successional trees (slow growing, shade tolerant, high wood density); and C4 grasses (comprising also pasture and agriculture) (Swann et al. 2015; Medvigy et al. 2009)."*

Response: As suggested, this sentence will be deleted in the revised manuscript.

22. Pg 4 L22-24: Deleted text: *"a series of", and "The size of the grid cell is"*

*heterogeneity of what? specify.*

Response: The heterogeneity being referred to here is the heterogeneity in ecosystem composition and structure within the climatological grid cells. The sentence will be revised to clarify this point.

23. Pg 4 L24: *describe the range either in degree, or in km.*

Response: As suggested the ranges will be specified in terms of both degrees and km in the revised manuscript.

24. Pg 4 L25-26 Deleted text: *"This characteristic of the ED2 model makes it suitable for a more realistic simulation of regions characterized by a mixture of natural and anthropogenically-modified landscapes."*

Response: As suggested, this sentence will be deleted in the revised manuscript.

25. Pg 4 L30-32 Deleted text: *"Disturbances are expressed in the model as annual transitions between primary vegetation, secondary vegetation, and agriculture (cropland and pasture) (Albani et al. 2006). Natural disturbance, such as wildfire, is represented in the model by the transition from primary vegetation (forest in the case of the Amazon) to grassland-shrubland, and subsequently to secondary vegetation (forest re-growth); the abandonment of an agricultural area is represented with the conversion from grassland to secondary vegetation, while forest logging is represented by the transition from primary or secondary vegetation to grassland."*

Response: This sentence is important for understanding how dynamic land cover transitions occur within the ED2 model. Since this is feature not typically incorporated in hydrological models we propose to retain this sentence in the manuscript.

26. Pg 5 L9: *Break a section here... call it 'ED2 hydrology module' or a name that suits you better.*

Response: As suggested, the text describing the hydrology will be placed in a separate section in the revised manuscript.

27. Pg 5 L14: *How is the soil/vegetation parameterization? ED2 uses a global scale dataset of soil, vegetation or it depends on application?*

Response: A description of the vegetation and soil parameterization of the ED2 model used in the study (a regional-scale parameterization used by Zhang *et al* 2015) will be included in the appendix of the revised manuscript.

28. Pg 5 L25: Deleted text: *"towards the basin outlet"*.

Response: in the revised paper, this sentence will be deleted as suggested.

29. Pg 5 L27-29: Deleted text: *"The original IPH-MGB model is composed of four different sub-models: soil water balance, evapotranspiration, intra-cell flow propagation, and inter-cell routing through the river network."*.
*Include additional and more recent MGB-IPH studies, you can check a list for reading at (www.ufrgs.br/hge/publicacoes/).*

*It important to stress that although the typical application uses a Muskingum-Cunge approach for river routing, the new MGB-IPH already allows the use of hydrodynamic solution and floodplain coupling (i.e. local-inertial, Pontes et al. 2015). In the Amazon River Basin application (Paiva et al. 2013) a full hydrodynamic solution was also required to solve low slopes and floodplain inundation characteristic of this basin.*

*This MGB-IPH model improvements must also be described and could be taken into the discussion as well.. along with the other models.*

*PONTES et al. (2015) Modelagem hidrológica e hidráulica de grande escala com propagação inercial de vazões. Revista Brasileira de Recursos Hídricos, vol. 20, n. 4. 2015.*

Response: We thank the reviewer for his/her suggestions regarding studies describing more recent MGB-IPH model developments. We will revise this section and the discussion section to include the more recent MGB-IPH studies mentioned by the reviewer.

30. Pg 5 L30: *It is enough to say the 'catchment and river routing methods' were utilized.*

Response: the sentence will be shortened as suggested.

31. Pg 6 L2-3: *groundwater or base reservoir? pick one. don't need any of the parenthesis.*

Response: the parentheses will be removed as suggested.

32. Pg 6 L6-7: *break the sentence at drainage network.*

Response: the sentence will be revised as suggested.

33. Pg 6 L7-13: *The DEM processing details are distracting and confusing at this point….Is this pre-processing or COTAT runs during simulation?*

*Also, assuming you are not worried with floodplain terrain at the moment, the technique can be briefly explained with something like..*

*".. from a digital elevation model (Reed, 2003; Paz et al. 2006)"*

*Which DEM resolution are you using?*

Response: The sentence will be revised to make clear that the steps described here were all pre-processing steps (including the application of the COTAT algorithm), and that the horizontal resolution of the DEM is 90m.

34. Pg 6 L14: *Muskingum-Cunge is a numerical scheme for the solution of the kinematic wave equation, which also accounts numerical diffusion to represent flow attenuation...*

Response: The sentence will be revised as suggested by the Referee.

35. Pg 6 L15: *river flow routing. What do you mean by river height?*

Response: we were referring to depth of the river cross-section. The sentence will be revised to indicate this.

36. Pg 6 L16-21: *This sentence is ok, but as it is about the model application in Tapajos, it should be described in the section 4.*

*You should describe better how would you parameterize at continental or global scale?*

Response: The sentence describing the specification of the river morphology will be moved to section 4 as suggested. To date, the ED2 biosphere model has been used for regional rather than continental-scale or global-scale studies (e.g. Zhang *et al*. 2015). Consequently, ED2+R is designed for simulations of river flows in specific catchments rather than global scale analyses.

37. Pg 6 L21-23: Deleted text: *"Later on, further studies successfully employed these statistical relationships to estimate river geometric parameters to carry out hydrodynamic simulations of the Amazon River system (Paiva et al., 2013; Paiva et al., 2011)."*

*This is not relevant for ED2+R method overview. Also, in Paiva et al. studies the authors derived their geomorphological relations, although the approach was similar to that of Coe et al.2008...*

Response: We thank the reviewer for pointing out the distinction between the Paiva et al. and Coe et al studies. We will revise this sentence to make clear that Paiva et al. (2011) developed their own statistical relationships based on Coe et al. (2008). The details about estimated river geometric parameters were requested by the Editor prior to the manuscript being sent out for review, and so we will retain them here.

38. Pg 6 L30: *Change name for 'Study case: Tapajós river basin'*

Response: in the revised manuscript, this section will be renamed as suggested.

39. Pg 6 L31: *Please, provide an overview of the Tapajós basin, such as hydrological features (i.e. precipitation, land-use, etc.)*

Response: As suggested, we will add a more detailed description of the basin (land use, altitude, geology, slope, soil depth and texture etc., as well as a climate description such as rainfall, evaporation, temperature, seasonality etc.) in the revised manuscript.

40. Pg 7 L1: *What is the grid/spatial discretization for hydrologic and river routing in this application? Which DEM was used?*

Response: ED2+R represents the simulation domain using grid cells of 0.5° resolution (~ 55 km). This is indicated in legend of Figure 3b, but will also be included here in the revised manuscript. The DEM used in the study is Shuttle Radar Topography Mission (SRTM)-derived DEM that has a spatial resolution of 3 arc-seconds for global coverage (~90 meters).

41. Pg 7 L3: *Please provide more details on landuse and land cover.*

Response: please see our responses to comment 39 above.

42. Pg 7 L6-8: Deleted text: *"Surface and subsurface runoff calculated for each cell with ED2 are connected with the three linear reservoirs of the routing scheme (Figure 2)"*
*this was described earlier.*

Response: the sentence will be deleted as suggested.

43. Pg 7 L9: *put the "two-step procedure" in the end of the sentence*.

Response: the sentence will be revised as suggested.

44. Pg 7 L12-14*: It means the ED2 was calibrated against discharges? after that alfa [sic] and beta are fixed?*

*this partitioning, alfa [sic] and beta parameters must be described earlier in sections 3 or 4.*

*In this way, this whole paragraph can be rewritten directly, as the calibration for alfa [sic], beta and CB, CI, CS are much similar.*

*Also, tau, CB, CI and CS nomenclature is superposing, thus confusing. Use one or another and fix figures/text accordingly.*

Response: In this technical note, we describe the calibration of the flow routing component of ED2+R: the parameterization of the ED2 terrestrial biosphere model was developed and evaluated independently using eddy-flux tower observations of carbon, water and energy fluxes and forest inventory observations of above-ground biomass dynamics. Further details can be found in Longo et al. (2014) and Zhang et al (2015).

The flow routing component of ED2+R was calibrated against discharge measurements for all the sub-basins. The flow partitioning is fixed for all the sub-basins: the two parameters alpha and beta were calibrated first, then the residence time (tau) for the three reservoirs (CB, CI and CS). With a second iteration, we calibrated again the alpha and beta parameters (fixed for the entire basin), and again the three reservoirs (CB, CI and CS) for each of the sub-basins obtaining the results presented in this manuscript.
In the revised manuscript we will bring the information presented in Annex B in section 4.

45. Pg 7 L15: *Explain, how did you set the alfa and beta intervals between 0 and 1?*

Response: The main point is that the biosphere model ED2 is organized in 2 reservoirs (surface and sub-surface), while the integrated model ED2+R is organized in three reservoirs (surface, intermediate, and base reservoirs). Alpha (ranging from 0 to 1 or 0% to 100%) represents the portion of ED2 surface runoff destined to the ED2+R surface reservoir. The remaining part (1-alpha) goes to the ED2+R intermediate reservoir. Beta represents a similar partitioning coefficient for the ED2 subsurface reservoir to the ED2+R intermediate and base reservoirs.

46. Pg 7 L17-18: **highest?*

*goodness-of-fit is often use to evaluate regression models or distribution models fitting..*

*while calibration is often based on minimization of objective functions.*

Response: Goodness-of-fit is a general term used in statistics to describe the ability of a model to describe a set of observations; however as noted by the referee the best goodness-of-fit is often obtained through minimization of an objective function. To avoid confusion, the word "highest" will be replaced by "best" and then make clear that this was achieved through minimization of a specific objective function that will be included in the manuscript.

47. Pg 7 L28-30: *Show detailed information (i.e. parameters, gages used, period, number of days filled, etc.) on this regression model for each gage where the interpolation was used.*

*Calibration of the model using filled data with high correlation (r>0.85) can produce improved statistics. Isn't this affecting your results? Was the interpolation step really necessary and why?*

Response: the interpolation of the gage observations was necessary to have continuous time series to calibrate the model. A table reporting information about time series and data filled will be added in the revised manuscript.

48. Pg 8 L6-9: *Explain volume ratio statistic.*

*The more recent Kling-Gupta efficiency metric (Gupta et al. 2009) overcomes some of the*

*Nash-Sutcliffe's flaws, please calculate it.*

*Gupta et al, 2009, Journal of Hydrology, doi:10.1016/j.jhydrol.2009.08.003*

Response: We used the Nash-Sutcliffe Efficiency metric because is still widely used and generally viewed as an appropriate indicator of model fitness. That said, we thank referee for this suggestion and would be happy to include the additional Kling-Gupta efficiency and at the Editor's discretion. Regarding the volume ratio statistic, it simply refers to the comparison of the total simulated vs. observed total water volume in the simulation period without consideration for the seasonal distribution of its flow.

49. Pg 8 L11: *You also have the opportunity to compare the results for*:

*ED2 versus ED2+ catchment routing versus ED2+catchment+river routing*

Response: The comparison suggested by the referee may provide an insightful intermediate set of modeling results; however, generating these results excluding river routing would require extensive modifications to the model code.

50. Pg 8 L12: *Focus on important numbers and features... some of interpretations could be better used in the discussion...*

Response: As suggested, this section will be rewritten, moving all interpretation to the discussion section.

51. Pg 8 L12: Deleted word: *"substantially"*

Response: The word will be deleted as suggested.

52. Pg 8 L14: *show time series for the seven basins.*

*Results shown in Figure 5 can be summarized in a Table, which will also facilitate the reading of metric values.*

Response: The time series for all seven sub-basins will be included in an Annex. We disagree with the referee that Figure 5, which shows the Observations versus predicted ED2 (non routed) and ED2+R time-series, can be adequately summarized in a table. We suspect however, that the referee may have intended to be referring to Figure 4, which displays the calibration and validation results. If so, we would be happy to replace Figure 4 with a table to facilitate the reading of metric values.

53. Pg 8 L15: Deleted word: *"substantially"*

*"goodness-of-fit"* replace with "*model skill or model performance"*

Response: The sentence will be revised in line with the reviewer's suggestion.

54. Pg 8 L18: *what do you mean by reasonable* [sic] *well?*

Response: The statement "reasonably well" will be clarified by including quantitative metrics of the model skill.

55. Pg 8 L19: *what do you mean by water availability?*

Response: "water availability" here refers to quantity (in terms of volume) of water in the basin. This will be added in parentheses afterwards.

56. Pg 8 L19: Deleted text: *"the application of"*

Response: The above words will be deleted, as suggested.

57. *Pg 8 L20-21: so.. the routing scheme, improved the routing when compared to the model with no routing... and?*

Response: Please see our response to comment #3.

58. Pg 8 L22: **higher?*

Response: the sentence will be revised in order to clearly identify the quantitative metrics that were improved.

59. Pg 8 L24: *reasonably well... what is this?*

Response: the sentence will be revised in order to clarify the quantitative extent of the improvement

60. Pg 8 L24-25: *i can't see this result anywhere in figures or graphics..or anywhere..*

Response: The statements are supported by the data presented in Figure 4. Specifically:

"*in the Upper Teles Pires and Upper Juruena, the model achieved the lowest NSE* (**this can be found in figure 4a - NSE**)*, and although water volumes are reproduced reasonably well* (**this can be found in figure 4c – Volume Ratio**)*, the seasonal variability is less accurate* (**this can be found in figure 4b - Correlation**)." In the revised manuscript, the sentence will be redrafted in order to better guide the reader through the relevant figures.

61. Pg 8 L26-28: *I can't see this anywhere..*

Response: A table reporting information about time series and data filled will be added in the revised manuscript and referred to here (please see our response comment #47 above). In addition, the sentence "The Jamanxim basin results, especially during the validation period, are affected by the very short and fragmented observation time series" will be moved to the discussion section.

62. Pg8 L29: *Explain FDCs briefly in methods*

Response: A description of the FDCs will be added to the methods section as suggested.

63. Pg8 L30: Deleted text: *"substantial improvement". at this point I know you are applying the routing scheme... use ED2 according ED2+R to avoid repetition*

Response: this sentence will be redrafted as suggested.

64. Pg 8/ L31: *"Excelent.." I can see the significant improvement... Use metrics, please.*

Response: As suggested, the verbal statement will be justified by including explicit metrics alongside it.

65. Pg 9 L2: *(Figure 6a, Figure 6b)*

Response: the wording will be modified as suggested.

66. Pg 9 L3: *What do you mean by general tendency?*

Response: The model overestimates the flow in the dry periods in both sub-basins. In the revised manuscript, this statement will be revised to include explicit metrics that quantify the extent of the overestimation.

67. *Pg 9 L4: (Figure 6c-6g)*

Response: the wording will be modified as suggested.

68. Pg 9 *L5: tend??*

Response: In the revised paper, this sentence will be will be revised to include explicit metrics quantifying the extent of the over-estimation

69. Pg 9 L6: *what happens in figure 6g, where ED2+R don't seem to improve lowflows when compared to ED2?*

Response: Figure 6g displays the FDCs of the same time series presented in figure 5. The last two sentences of section 5 states: "For downstream subbasins, Lower Juruena and Lower Teles Pires, flood duration curves show a general tendency of overestimating the lowest values of the distribution (panels c to g in Figure 6). This is also evident in the multiyear hydrograph (Figure 5), which shows that the ED2+R tend to overestimate the observations during the dry seasons of the period under consideration."

In the revised manuscript, Figure 6g will also be mentioned in the last sentence.

As we discussed in section 6 (page 9 lines 15-25), we believe this is likely due to the coarse resolution of the grid-cells, and interactions with deep groundwater. It is true that in the downstream part of the basin the model performs better and these issues are less evident (page 9 lines 20-22); however, during the dry season the limitations of the model performance are also evident in the downstream part of the basin.

This aspect will be clearly stated in section 6 of the revised manuscript.

70. Pg 9 L9: *What is a simple one-way routing scheme? Where did this come from?*

Response: This means that ED2 and the routing scheme are not fully coupled. The biosphere model and the routing scheme are linked with a one-way integration. Therefore, the biosphere model underestimates the extent of the seasonally flooded ecosystems, a relevant aspect as mentioned in the reference the reviewer suggested for the introduction (Cole et al. 2007 Ecosystems (2007) 10: 171–184 DOI: 10.1007/s10021-006-9013-8). This aspect is presented as a limitation of the model, as clearly stated in page 10, lines 17-22.

71. Pg9 L10-11: Deleted text: *"substantially"*, and *"the model's ability to reproduce daily water flows through a large river basin"*. Replace with: *"the performance of simulated daily discharges.."*

Response: this sentence will be modified as suggested.

72. Pg 9 L12-13: *Don't repeat literal results...*

Response: the sentence will be deleted in line with the referee's suggestion.

73. Pg 9 L 15-18: *I'm not sure, there are other things to consider like: Can you explain why this would deep groundwater interactions are important in the Tapajos basin? What's the role of river hydraulics? What is the importance of evapotranspiration in this basin? How does this affect the model ability to simulate local to global scales? Can't you calibrate or improve ED2 hydrology model parameterization to fix this? Isn't this asscoiated to the calibrated alfa and beta at the first step?*

Response: Analysis by Longo et al. (2014) showed that the ED2 model's evapotranspiration rates compare well to flux tower measurements. We also are confident that the parameters alpha and beta in the routing scheme are calibrated near-optimal values. We therefore believe it is likely that much of the residual error is arising from complexities associated with deep soils present in the headwaters of the Tapajos. In particular, the model application developed, soil layers are only represented to a depth of about 8 meters, which might be too shallow to more realistically represent the conditions in the headwaters of the Tapajos. We will revise the sentences to clarify these points.

74. Pg9 L19-20: *greater marginal contribution? Do you mean baseflow to total flow? show this...*

Response: Surface flow accumulation is, by definition, lower in the headwaters. Therefore, in relative terms, the role of baseflow is more relevant in those portions of any catchment. This will be clarified in the revised manuscript.

75. Pg9 L21-22: *"masked by?" What do you mean by "larger rainfall-runoff contribution?" Are you trying to say the river storage is more important than*

*the groundwater?!*

Response: as mentioned in the previous comment, in relative terms, the contribution from surface flow is larger in the downstream part of any catchment. This will be clarified in the revised manuscript.

76. Pg9 L23-25: *So what do you mean by this? Are these the only differences? What about the precipitation and climatological datasets, landuse vegetation? Moreover, how is the river parameterization x river routing method x model performance affected at this basin scale?*

Response: in our opinion, higher resolution climatological data, vegetation, and land use datasets, jointly with a finer resolution of the hydrological grid, would improve the performance of the model. In the revised manuscript, we will better clarify these aspects and provide evidence from literature to support our hypothesis.

77. Pg9 L26: Deleted word: *"principal"*

*better than what?*

Response: As suggested, the word "principal" will be deleted and the sentence will be revised to make clear that the comparison is between ED2+R and the native ED2 formulation.

78. Pg9 L27: *why are you repeating this idea?*

Response: the sentence will be revised as suggested.

79. Pg9 L28: *what is: local and regional scale? Also, it was said before that the ED2+R showed limitations to simulate some groundwater processes in headwaters... Is ED2+R really prepared to run at global scale? What about the computational effort to run the ED2+R in comparison to ED2? What about its ability represent more complex river systems (i.e. floodplains, backwater effects)?*

Response: As noted above (see our response to comment #36), the current ED2+R formulation is not designed to conduct global scale simulations. It does, however, incorporate ecosystem responses to global environmental change drivers such as anthropogenic climate change, increasing levels of atmospheric carbon dioxide, and changes in land cover. We will revise the sentence to clarify this distinction, and clarify what is meant by local and regional spatial scales ($10\text{-}10^6$ $km^2$). The current ED2+R formulation is not designed to simulate more complex and detailed hydrological dynamics such backwater effects. This will also be noted in the revised manuscript.

80. Pg9 L32: *What are the current limitations? Where is ED2+R when compared to other more sophisticated models?*

Response: The limitations of the ED2+R are discuss concluding section (Page 10, lines

12-22)

81. Pg 10 L 3-9: Deleted text: *"Biosphere models are excellent tools to study hydrological dynamics under climate and land use/land cover changing conditions. These models are usually set to simulate long periods in large regions, usually at global or continental scales. Their ability in reconstructing the water balance at relatively fine geographical and temporal resolution, taking into consideration global environmental changes makes them powerful instruments for hydrological simulations. In order to translate the results of the land surface simulation in terms of river flows, the simulated results need to be processed using a hydrological routing scheme."*

*This is background...*

Response: As suggested, the above text will be deleted in the revised manuscript.

82. Pg 10 L15-17: *"were linked to the relatively resolution of the model and the rough representation of groundwater flow typical of this kind of models."*

*see comment in discussion..*

Response: please see our responses to comments #69 and #73 above.

83. Pg 10 L18: *"one-way integration"*

*what so you mean by this? and why is this relevant?*

Response: please see our response to comment #70 above.

84. Pg 10 L20: *"flooded ecosystems"*

*not quite... muskingum-cunge is not really appropriate for floodplain dynamics, especially in large tropical floodplains.*

*also, what do you mean by flooded ecosystems?*

Response: please see our response to comment #70 above. In this first attempt to integrate ED2 and the river routing scheme, our goal was to improve ED2's ability to predict the streamflow. The feedbacks from the river routing scheme to the ED2 can now determine the grid cells across the domain that are likely to be saturated (near the river paths, for example). For example ED2 can potentially use this information to reduce the growth (or increase the mortality rates) of plants that are more sensitive to inundation.

85. Pg 10 L20: *could be? Isn't it?*

Response: the wording will be changed as suggested.

86. Pg 10 L27: *Annex A: I don't think this section is needed.*

Response: Annex A will be deleted from the revised manuscript as suggested.

87. Pg 11 L24: *The only criteria here was the ENS?*

*This is confusing:*

*1.Did you calibrate the ED2 (without +R)first?*

*2. Do you calibrate alfa, beta with ED2+R or ED2 only?*

*Explain clearly.*

Response: Please see our response to comment #44 above.

88. Pg 11 L29: *"almost completely?" "uninfluential?"*

Response: In our analysis we did not consider the first 5 years of simulation (1970-1975), and calibrated the model using the data for the period 1976-1992 (figure 5). As a result of this long model spin-up, the setting of the initial conditions of groundwater, especially in the upstream part of the basin, are almost negligible (figure B.2). To clarify this point, the sentence "Changes in initial groundwater contributions in the downstream part of the basin are almost completely uninfluential" will be replaced by: "Due to the five year spin-up period, changes in initial groundwater contributions in the downstream part of the basin had minimal impact"

89. Pg 12 L1: *Figure B.3*

*How did you set the range of variation of each parameter?*

*Does the final parameters have a reasonable physical meaning?*

Response: The final parameters have a reasonable physical meaning given the large area of the grid cells. The range of variation was determined maximizing the calibration results.

90. Pg 19 L9: *In the figure caption, erase text in parenthesis*

Response: The text in parentheses will be removed as suggested.

91. Pg 21 L1: *Figure 4: a table would do it.. i think it is hard to read the values.*

Response: As noted earlier (see response to comment 52), the figure will be replaced with a corresponding table as suggested.