

Dear the reviewer,

We greatly appreciate your precious time in reviewing our manuscript. We addressed each of your comments in the revised manuscript. Our responses to your comments are listed below and marked in blue following each specific comment. By the way, due to unexpected authorship issue, we apologize for our late response to your comments.

If you have further suggestions for changes, please let us know.

Dr. Guoping Tang
On behalf of co-authors

Interactive comment on “Does consideration of water routing affect simulated water and carbon dynamics in terrestrial ecosystems?” by G. Tang et al.

Anonymous Referee #1

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The manuscript by Tang et al. compares two versions of the same hydrologic model (with and without water routing) to assess the role of hydrologic connectivity on ecosystem fluxes – in particular transpiration, primary productivity, autotrophic respiration, and heterotrophic respiration. This is a relevant topic, certainly of interest for readers of HESS, as it tackles the broader question about the role of hydrologic connectivity in shaping ecological and biogeochemical patterns at the landscape scale. The manuscript is well-written and generally clear. Figures are illustrative and results presented in a concise and clear way. I have some concerns, however, regarding the way the analyses are performed: as the results stand, they do not fully address the main objectives posed in the introduction (see below). One other potential critique is that the model is not validated against biogeochemical fluxes, as the author very openly acknowledge on P12550, but I do not see this as a real problem, given the more theoretical goals of this analysis.

Response: We appreciated your good comments. We agree that there are lack of observed data to further validate the model's performance as commonly encountered in many other model-based studies. We revised the manuscript addressing your comments and based on new model simulations. We conducted new model simulations because after fixing one bug in the original model code. The results from new model simulations demonstrated that consideration of water routing has significant effects on simulated carbon and water dynamics in terrestrial ecosystems. For example, we found that the simulated water fluxes (evaporation, transpiration and total AET) are greater under simulation with water routing than those without water routing (see sections 3.3 and 3.4 in the revised manuscript). In addition, we compared simulation results under two contrasting scenarios, i.e., one “dry” and another “wet” scenario, and test if the effects of consideration of water routing have greater effects on simulated carbon and water dynamics under the “dry” scenario than under the “wet” scenario. The comparison demonstrated that the effects of the consideration of water routing on simulated carbon and water dynamics are more remarkable under the “dry” than under the “wet” scenario (see section 3.6 in the revised

manuscript). As you pointed out, the main goal of our study is to test the importance of water routing in spatially distributed hydro-ecological models from a theoretical perspective. We thus hope that the lack of data to further evaluate the model's performance is understandable. We are going to apply this model to a watershed located in semiarid and arid ecosystems (A Great Basin watershed) and will thus continue to test the model's performance.

Main issue: Basically, the authors demonstrate that water routing has no or very minor effect on ecosystem functioning (and on the predicted river discharge). This conclusion seems too restricted to an ecosystem that appears to be energy rather than water limited. My impression is that the proposed approach to assess the effect of routing is sound, but the analyses should span a wider range of hydrologic conditions to conclude in which conditions routing matters or not. I would suggest performing a systematic analysis of the same watershed, with same model parameterization and initial conditions, but using altered rainfall scenarios. For instance, the measured rainfall during the growing season could be decreased by different amounts to establish a set of drier scenarios. I would expect (and I could be very wrong!) that the watershed would become progressively more water limited as rainfall is decreased, therefore showing some stronger effects of water routing. Below some rainfall threshold, hot spots of biogeochemical activity would remain only where moisture is concentrated. In these conditions, routing would provide the mean to concentrate rainfall and allow these hot spots to exist. Without these additional analyses, I am not sure the conclusions can be much generalized in space and time. If these analyses still show that routing does not matter (except for the moisture fields), that would also be an important result and would stimulate discussion on this topic.

Response: We appreciated your good comments. Our new simulation results indicated, even in this humid watershed, that the consideration of water routing has important effects on simulated carbon and water dynamics. After fixing a bug in the model code, we repeated model simulations and the consequent results indicated that the simulated water fluxes, i.e., evaporation, plant transpiration and total AET, from the land to the atmosphere were greater respectively under simulation with than those without water routing (see section 3.3 in the revised manuscript). In addition, the simulated carbon fluxes, i.e., NPP, soil autotrophic and heterotrophic respiration when averaged for the entire watershed, were smaller respectively under simulation with water routing than those without water routing (see section 3.4 and 3.5). In addition, we compared simulation results based on two contrasting climate forcing scenarios, one "wet" and another "dry" scenario (The dry scenario with altered daily precipitation). The comparison indicated that the effects of consideration of water routing on simulated monthly carbon and water dynamics in 1995 were more remarkable under the "dry" scenario than those under the "wet" scenario (see section 3.6 in the revised manuscript). We presented and discussed related results in the revised manuscript. Based on new simulations and comparisons, we revised our main conclusions. In addition, the revised Fig. A2 (in supplementary materials) also demonstrated that simulated carbon and water dynamics were distinct from each other between simulation considering water routing and ignoring water routing.

Minor issues:

- Abstract: the last sentence is long and a bit convoluted

Response: We revised this sentence (see the "Abstract" section in the revised manuscript).

- Introduction: little credit is given to the vast amount of work on spatial organization of plant-hydrologic systems in semiarid ecosystems – e.g., recent work by Caylor and coworkers (Princeton U.), or by Thompson, Katul and coworkers (Duke U.). In more mesic systems such as the one studied here plant-water interactions are probably weaker, in the sense that strong spatial patterns may be less prominent. Nevertheless, similar ideas on the role of water concentration mechanisms still hold across climates.

Response: We cited the following two papers that are closely related to our study in the revised manuscript:

Thompson, S., G. Katul, et al. (2011). "Unsteady overland flow on flat surfaces induced by spatial permeability contrasts." *Advances in Water Resources* **34**(8): 1049-1058.

Caylor, K. K., S. Manfreda, et al. (2005). "On the coupled geomorphological and ecohydrological organization of river basins." *Advances in Water Resources* **28**(1): 69-86.

- P12544: the values of the empirical sensitivity parameters seem a bit arbitrary: how were they chosen? Why in the case of no routing the sensitivity parameter is still >0 ? Is s_{max} equivalent to the soil porosity multiplied by the soil depth (i.e., the max storage capacity)? Also, on line 8, use small "s" for saturation deficit to be consistent with Eq 1.

Response: The values for the sensitivity parameter used for simulation with and without water routing are calibrated values based on the model's calibrations for the period 1992-1993. The "s_max" is generally the product of soil porosity and soil depth. However, the magnitude of "s_max" is subject to the decay parameter of the soil porosity in the soil vertical profile defined in the model simulation. We changed the uppercase "S" to lowercase "s".

- First line of Sections 2.3 and 2.5: in both instances I would re-phrase as " : : time series of daily: : :"

Response: Revised.

- Results section: I wonder about patterns in soil C, which partly drives soil heterotrophic respiration in the model. Do C distributions across the landscape change depending on routing?

Response: Based on our new simulations, the spatial patterns of simulated soil carbon also differ between the two contrasting simulations, i.e., one with and another without water routing.

- Discussion section: the implicit assumption throughout the discussion (and the rest of the paper) is that the mesic forest used to parameterize the model is the only ecosystem of interest. It might be worth reminding the reader that statements such as "75% of seasonal variations in soil respiration can be explained by variations in soil temperature" apply only to such a system, and not in general.

Response: We revised related text according to your suggestion (see section 4.5).

- Conclusions, point iii: lower productivity? This seems inconsistent with previous (L23, P12548) and subsequent statements that productivity was little affected by water routing.

Response: We revised the third conclusion based on new simulations, under which the simulated forest NPP, when averaged for the entire watershed, was 8% smaller under the simulation with water routing (3.33 gC m⁻²) than that without water routing (3.60 gC m⁻²) (see conclusion section: lines 529-536) .

- Conclusions, closing statement: while I fully agree on qualitative terms, this is not what your results show. Results clearly show that modeling routing does not matter when it comes to prediction of discharge and watershed-scale fluxes (even plot scale fluxes!). Therefore adding routing to models is not necessary, unless one wants to study moisture patterns that anyway don't matter. I am of course stretching the argument too far, but the point I would like to make (see also above) is that the chosen case study of an energy limited ecosystem is perhaps not the best one to show the role of routing and hydrologic connectivity.

Response: We totally agree with your comments. Our new simulation results strongly indicated that consideration of water routing greatly affects simulated carbon and water dynamics even in this mesic ecosystem and such effects were more remarkable in water-limited conditions. We revised our conclusions based on new results and findings (see last paragraph in "Conclusion" section in the revised manuscript.