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, since we started revising our manuscript in early of January. Hopefully, you are not surprised we responded to your comments so quickly.

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 #3

Received and published: 30 January 2014

The paper addresses relevant scientific questions in regards to the representation of routing within process based hydrologic models. The paper is very clearly written and the figures informative. The authors have begun to explore the questions of the impact of spatial variability on watershed functioning.

Response: Thanks for your good comments.

Comments: Direction of flow routing: Is base/return flow routed based on topographic gradients or does some fraction of runoff enter all downslope neighbors?

Response: When water routing was considered in the simulation, in each grid cell, the surface and subsurface runoff were calculated first and then routed proportionally to its downslope neighbors. The fraction of water routed from one patch to one of its downslope neighbors was calculated based on slope, elevation and the patch widths between the two patches. The summation of all fractions from one patch to its downslope neighbors equals one. Below is a good example to demonstrate the fractions of water routed from one patch to its all downslope neighbors in R-RHESSys:

The total number of cells for the Biscuit watershed is 10772. The patch "1" has highest elevation and four downslope neighbors "2", "3", "4" and "5". The fractions of subsurface flow routed from patch "1" to its downslope neighbors "2", "3", "4", and "5" are 0.18829359, 0.24842674, 0.31355479, and 0.24972489, respectively. The summation of "0.18829359 + 0.24842674 + 0.31355479 + 0.24972489 "is 1.0. These fractions also applied to subsurface flow when water routing was considered in the model simulation. See section 2.2 (lines 174-185) for more information about routing vs. non-routing.

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1     1    840    0.0    14.0 1120.5   1.000000     0 0.141804    4
            2     2    839  0.18829359
            3     3    840  0.24842674
            4     4    840  0.31355479
            5     5    839  0.24972489
2     2    839    0.0    15.0 1115.8   1.188294     0 0.064443    4
            1     1    840  0.00000000
            4     4    840  0.19490071
            5     5    839  0.36278996
            6     6    839  0.44230935
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Initial conditions: It is not clear if each scenario was spun up individually or if the same initial condition was used for both scenarios. The supplementary data only shows the equilibrium states of one simulation. If the same initial condition has been used it would not be possible to evaluate what observed changes are due to routing, and what changes are due to the initialization.

Response: Yes, all model simulations started from the same initial condition and then were spun up for 240 years. We clearly stated this modeling protocol in the revised manuscript (Section 2.5 and lines 226-227). The model's behavior in simulating water and carbon dynamics are extremely similar between simulation considering water routing and that ignoring water routing. However, they are distinct from each other in term of magnitudes in simulated carbon and water fluxes dynamics as shown in Fig. A2 in the revised manuscript, which included the model's behaviors under simulation ignoring water routing. The new Fig. A2 can help address your following comments (see comments on section 2.5).

Section 2.5: the authors have chosen to evaluate the model over the period 1994-1995. The reasoning behind this decision was that the COOP station data was most consistent over this period. Considering both simulation scenarios are being forced by the same climate time series, inconsistencies in the forcings would be expressed in both simulations and could be accounted for during comparative analysis of the two scenarios. Additionally, examining the supplementary data, there does seem to be significant variability in the land surface response over the forcing data set period (most highlighted by the LAI). Examining the impact of routing during periods of low LAI versus periods of high LAI would perhaps indicate regimes over this climate record where water limitation drives the land surface response versus energy limitation. Perhaps a discussion of what the inconsistencies in the forcing data sets would help justify this decision.

Response: We totally agree with your comments. In our previous manuscript, it seemed that consideration of water routing has no significant effects on simulated carbon and water fluxes. Your suggestion on comparing simulated carbon and water fluxes between a year with low LAI and another with high LAI will definitely test if consideration of water routing has greater effects on simulated carbon water dynamics on different climate forcing conditions, for instance, "wet" vs. "dry" years, or "warmer" vs. "cooler" years. It can also tell if water limitation or energy limitation droved such variation as shown in Fig. A2. In fact, other two reviewers also made a similar comment. To address your comment and also give consideration to other two reviewer's comments, in the revised manuscript, we compared simulation results between two contrasting climate forcing scenarios, one "wet" and another "dry" scenario (The dry scenario with altered *daily precipitation for year 1995). The comparison indicated that the effects of the 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. We presented and discussed related results in the revised manuscript (sections 3.6 and 4.6). In addition, we fixed one bug in the original model codes and repeated all simulations using the same climate forcing data as we used before. 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. Specifically, our new 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 water routing than those without water routing. 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. Based on new simulations and comparisons, we revised our main conclusions. I wish that our new simulations and the revised Fig. 2A could address your good comments here. For example, we compared simulations between "wet" and "dry" forcing scenarios, in which temperatures were kept identical, thus minimizing effects of energy difference on simulated carbon and water dynamics. We also believe that comparing simulated carbon and water fluxes between a year with high LAI and a year with low LAI will lead us to draw similar conclusions, as demonstrated by Fig. 7 in the revised manuscript.*

Table 2: The water table and saturation deficit have altered with the routing case results in less water being stored on the landscape. Additional water balance components would be useful (ie stream flow and base flow) in order to close the water budget. The supplementary data does indicate that mean base flow over the evaluation period is significantly different between the two scenarios. The simulated LAI would also be beneficial to add to this table.

Response: We added simulated annual average LAI values to Table A1 in the supplementary materials.

Section 4.5: To aid this discussion, the RA and RH equations would be useful.

Response: We totally agree with your good suggestions. However, the calculations of soil autotrophic and heterotrophic respiration were somewhat complex in the model. It involves many equations (>4) or sub-routings (or sub models). For example, soil RH (heterotrophic respiration) in RHESSys involved the decomposition of labile litter, Cellulose litter, and lignin litter. The decomposition also involved processes such as fast microbial recycling of labile litter, slow recycling of Cellulose litter, and recalcitrant soil organic matter formation. It is thus a challenge to use one or two equations to summarize the whole processes of soil heterotrophic respiration. Related information about soil decomposition was available from Thornton (1998), Lloyd and Taylor (1994) and Parton et al. (1996). The calculation of soil autotrophic respiration is simpler but still consists of a list of respirations relevant to fine roots, coarse roots, dead fine root, and dead coarse roots. In section 4.5, we clearly stated that the calculation of RA was a function of temperature while the calculation of RH was a function of both temperature and soil moisture. We think these are key information to help readers understand the difference in simulated RA and RH between the two contrasting simulation. We wish our response here were acceptable.

Figure 2: All y labels are SF, two should be BF

Response: Revised and see Fig. 2 in the revised manuscript.

Table 1: Can the active zone depth be greater than the soil depth?

Response: Yes, the depth of active zone is greater than the depth of soil as listed in Table 1.