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Reply on RC1

Yujie Wang and Christian Frankenberg

Author comment on "Technical note: Common ambiguities in plant hydraulics" by Yujie Wang and Christian Frankenberg, Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-96-AC2, 2022

The technical note from Yujie Wang and Christian Frankenberg focuses on still very poorly investigated area of modern plant ecology and hydrology focusing on describing and parameterizing the plant hydraulic properties as key parameters for simulation of plant or canopy transpiration and/or water uptake.

The paper is well written and can be interesting for modelers of plant hydrology to parameterize the transpiration and water transport in plant communities. The manuscript is in scope of J. Biogeoscience and can be publish in the journal after some revision.

[RESPONSE]

We thank reviewer 1 for the recommendation, and we have revised the manuscript carefully to add more items where researchers need to be cautious. See our detailed response below.

Actually, I guess a few points have to be additionally discussed in the paper.

1. All tall plant and trees are characterized by a non steady-state water transport through the soil - root- stem -branch - atmosphere system, i.e. the water fluxes at different plant segments is different e.g. root water uptake is not equal transpiration at some short time intervals. Plant tissue and leaves accumulate water which can later be used for transpiration…

[RESPONSE]

Modeling plant hydraulics in steady state or non-steady state is an option for users. In fact, modeling non-steady state flow will be more realistic. However, this requires more complicated models as the flow rate is not consistent any more. Further, the model parameterization is much more difficult. Researchers should choose the model with adequate complexity, otherwise the results may not be reliable. We mention this in a new section in the revision. Further, to better illustrate what we meant, we cross-ref the section to Figure 3 (section 6 in revision). Changes related (main text may differ slightly if we receive new comments from the reviewers and community, hereafter):

- **"Plant hydraulic models have various complexities depending on the various aims of research and difficulties in model parameterization (Tyree and Ewers, 1991; Tyree and Zimmermann, 2002). In terms of flow profiles, the models can be categorized to steady state and non-steady state models. The steady state models use a constant flow rate within roots, stem, and leaves. The non-steady state models employ a changing flow rate within or among different tissues given the water exchange between xylem and capacitance tissues. In terms of the model complexity, the models range from a single element to a xylem network (say multiple roots and multiple canopy layers). Further, hydraulic conductance of an element may change with the growth of plants; for example, the drought legacy, maximum hydraulic conductance, and VC vary with the stack of new tree rings (McCulloh and Sperry, 2005; Cai and Tyree, 2010). Although more complex models may better represent the water flow and pressure profiles within the plants, increasing difficulties in model parameterization makes these more complex models less appealing to users. However, inappropriate model selection could result in biased results, for instance, modeling plant hydraulics at steady state for plants with high water capacity and ignoring vessel tapering effect when modeling xylem growth. Thus, it is important to select plant hydraulic models with adequate complexity in topical research. See the section below for a detailed example of how reduced model complexity (ignoring VC segmentation) may bias the modeled hydraulic risk and thus stomatal responses."**

2. Xylems of woody plants are very heterogeneous and characterized by different hydraulic conductance (for example along radial profile). Ignoring such effect can result in biased model results.

[RESPONSE]

We have this issue addressed along with the one above, as they are part of model complexity. Changes related:

- **"In terms of the model complexity, the models range from a single element to a xylem network (say multiple roots and multiple canopy layers). Further, hydraulic conductance of an element may change with the growth of plants; for example, the drought legacy, maximum hydraulic conductance, and VC vary with the stack of new tree rings (McCulloh and Sperry, 2005; Cai and Tyree, 2010)."**

3. One of a key objectives of your study is to "highlight the commonly seen ambiguities and/or misunderstandings in plant hydraulics" including different sections and particularly the "(4) stomatal model representations". Unfortunately this section is very poorly discussed in the manuscript.

[RESPONSE]

Thanks for pointing this out, and we have now renamed section 5 to "Stomatal model representation", and added more description. Changes related:

- **Section "Stomatal model representation".**
- **"Plant hydraulics-based stomatal models are gaining increasing interest in the vegetation and land modeling communities (e.g., Kennedy et al., 2019; Sabot**

et al., 2020) as they predict stomatal closure at dry environmental conditions without employing an arbitrary tuning factor (often known as the β factor) (Powell et al., 2013). For instance, the recently developed optimality theory-based models propose that plants should balance the gain and risk associated with stomatal functioning (Wolf et al., 2016; Sperry et al., 2017). When plants open their stomata more, plants gain more photosynthetic carbon, but lose more water and have higher risk in hydraulic failure; therefore, plants are supposed to find a sweet zone to maximize the difference between the gain and risk. These optimality theory models, particularly those weigh the risk based on plant hydraulics, show comparable or better predictive skills compared to the statistical approaches (Anderegg et al., 2018; Eller et al., 2018; Venturas et al., 2018; Wang et al., 2020; Sabot et al., 2022). However, a common mistake when using plant hydraulics-based models is that one does not follow the original model formula or hypothesis."

Specific comments.

"The risk of stomatal opening" is not the best term for the sentence from ecological point of view. Stomatal opening and closing are very important physiological processes in plants. It is better to use the term e.g. "stomatal response", "stomatal functioning", or any. So, I suggest to reformulate the sentence.

[RESPONSE]

We have added more description related to stomatal optimality theory, and reworded this sentence as well to be more clear. Changes related

- **"For instance, the recently developed optimality theory-based models propose that plants should balance the gain and risk associated with stomatal functioning (Wolf et al., 2016; Sperry et al., 2017). When plants open their stomata more, plants gain more photosynthetic carbon, but lose more water and have higher risk in hydraulic failure; therefore, plants are supposed to find a sweet zone to maximize the difference between the gain and risk."**
- **"For example, the Sperry et al. (2017) model defines the risk associated with stomatal functioning (Θ) as"**