

Geosci. Model Dev. Discuss., referee comment RC2
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Comment on gmd-2021-270

Valentin Couvreur (Referee)

Referee comment on "Tree Hydrodynamic Modelling of Soil Plant Atmosphere Continuum (SPAC-3Hpy)" by Marcela Silva et al., Geosci. Model Dev. Discuss.,
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General comments:

In this manuscript, the authors describe the one-dimensional numerical model of tree hydrodynamics SPAC-3Hpy with explicit Richards-like solutions of flow in soil, root, and stem domains. It is proposed to validate it against analytical solutions of water flow in porous media, and against tree transpiration data. The scope is of great interest to the readership of Geoscientific Model Development. Overall, the study is interesting, well explained and provides clear illustrations.

My main concerns regarding publication in GMD are (i) the need for clarifications and small improvements that would facilitate the interpretation of the manuscript, (ii) the validation against transpiration data that I think does not meet the quality of the rest of the manuscript, and (iii) the lack of a proper contextualization of the model relative to the galaxy of existing tree hydrodynamics models that could be developed in a discussion section.

Specific comments:

Reviewer Comment 1 (RC1), line 11 (L11): The term "hydroactive" xylem is a bit odd as the process of water flow in xylem is passive as described in the introduction of the paper. Also, throughout the paper the authors seem to use the term "xylem" when referring to the stem (e.g. also at L84). This is confusing as there is xylem in roots and leaves too. I would suggest to revise the wording.

RC2, L12: I am enthused that the authors made their model open access. It also seems that the code is open source, which is even better I believe. If that is correct, why not making it explicit in the text?

RC3, L21-22: I think the sentence needs to be completed. Upward flow of water in 20 m trees would also be possible without the tension-cohesion mechanism, using an osmotic pressure difference of 0.2 MPa between soil and xylem. The tension-cohesion theory explains that this upward flow is possible without an osmotic driving force, along a continuum of liquid water under tension.

RC4, L40-42: Root water uptake compensation and hydraulic redistribution can also be

modelled with “electric circuit” models that do not account for the plant water capacitance (see e.g. Meunier et al. (2017); Kennedy et al. (2019)). A major progress with the capacitance is that water fluxes along the stem do not have to be vertically equal simultaneously (e.g. as observed in Sperling et al. (2012) in palm) and that the integral of root water uptake does not have to match the integral of transpiration at a given time due to variations in stem water storage.

RC5, L63-64: Similarities with FETCH and FETCH2 are mentioned but differences are unclear and should be clearly explained. A discussion section could as well discuss the specific interest of SPAC-H3py relative to the broader diversity of tree hydrodynamics models.

RC6, Figure 1: It is good that variables appear in figure 1, so that connections to the equations can be done. However, several of these variables have not been defined at this point, which complicates the interpretation of the figure. There is room for it in the caption, or in the main text already.

RC7, L70-72: At this point it is not clear if radial resistances between the bulk soil, root surface and root xylem are considered. It is particularly important to specify it in the overview as they are frequently viewed as the largest resistances in series of the soil plant hydraulic continuum.

RC8, L99: I realize it is implicit, but probably worth specifying that the “soil capacitance” is the “soil water capacitance”. The same goes for the root and stem water capacitances.

RC9, L99: Going through the equations I frequently wondered if parameters were constants or could vary in space. For instance, stem cross-sectional area, saturated hydraulic conductivity (here K_m I believe) and sensitivity to cavitation (that I guess relate to the water capacitance parameter) vary along tree stems with substantial consequences on the nonlinear vertical water potential profile (Couvreur et al., 2018). It would be worth discussing briefly if such vertical variations of hydraulic parameters can be accounted for in SPAC-3Hpy.

RC10, L110: I found it confusing that “ S_x ” does not have the same units as “ S ” (also in equation 6). The same goes for “ A_{ind} ” whose symbol suggests area units like “ A_x ”, “ A_s ” and “ A_r ”. How about explicitly writing “ A_r/A_s ” instead of “ A_{ind} ”?

RC11, L122: The use of the subscript (z) for parameters like “ r ” but not variables like “ θ ” is a bit confusing. Why not using the subscript (z) for all variables and parameters that vary in space or mention it in a table? The same could be done for those varying in time.

RC12, L122: As it is presented, it is hard to understand why a vertical profile of relative root surface areas multiplies a normalized vertical profile of root mass in equation 4. Both seem to do the same job, don’t they? In the discussion section, it would be interesting to discuss this formulation of the radial water flux in the broader context of existing models (e.g. De Jong Van Lier et al. (2008)).

RC13, L129: It is unclear if “ T ” is normalized by the soil, stem, or leaf surface area. Please clarify it when first introducing the variable.

RC14, Figure 6: While I found the comparison with the analytical solution convincing, I am a bit more sceptical about the validation against transpiration rate data. To argue on the need for the new features of SPAC-3Hpy using a validation, I feel it would be relevant to show that the increased complexity and number of parameters is compensated by a substantial increase in the accuracy of the model predictions, possibly justified by the

result of an Akaike test. Here the validation rather looks like an example run that fits reasonably well observed transpiration rates. However, with so many parameters involved, one could hardly imagine a poor fit of the transpiration data. This validation attempt that I feel is a bit oversold could be sent to appendices and replaced by a simple discussion contextualising the diversity of tree hydrodynamics models revolving around SPAC-3Hpy and explaining why we need this model, and which gap it will fill.

RC15, Figure 6: It seems like there is a problem with inconsistent temporal scales in the top and bottom parts of figure 6. I realize that in a model with stem water capacitance, transpiration and water uptake may happen at slightly different times, but morning transpiration should come slightly before root water uptake, not the opposite. This issue is visible in the first peak. In the last peak, the temporal shift is in the opposite direction, possibly a bit off too. Please could you check the time scales?

Best of luck with the next steps.

Valentin

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