Hydrology and Earth System Sciences Discussions

Hydrol. Earth Syst. Sci. Discuss., referee comment RC2 https://doi.org/10.5194/hess-2020-671-RC2, 2021

Review on hess-2020-671

Anonymous Referee #2

Referee comment on "Plant Hydraulic Transport Controls Transpiration Response to Soil Water Stress" by Brandon P. Sloan et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-671-RC2, 2021

The study analysed the impact of heuristic β-type water stress formulations, commonly adopted to many land-surface schemes in terrestrial biosphere models and identifies when such a formulation diverges for more detailed models that include explicit formulation of plant hydraulics. Additionally, it proposed a new dynamic β -type formulation that "emulates" with a very reduced complexity the limitations that originate from plant hydraulics. The study is focused and very well written, and clearly within the scope of HESS. I found particularly insightful the analysis with the simple plant hydraulic model that clearly shows when plant hydraulics are expected to play a major role, and the dynamic β model which can be easily adopted by exiting TBMs. I can suggest the manuscript for publication after the following comments have been addressed:

Specific comments:

- I believe that information from S4 should move to the main manuscript. While reading the manuscript I was confused whether soil moisture dynamics were simulated, or if soil moisture and soil water potential were set to the observed values at the site. I could also not tell what ψs corresponds to (i.e. root zone average potential? potential of root average soil moisture?). I appreciate that the authors like to present a focused manuscript, but bringing this information in the main article will improve itsreadability.

  BPS: Thank you for the comment. Following this and a similar comment from Reviewer 1, we will update Sect. 2.4 to include additional details from Sect. S4 explaining the use of soil moisture measurements at 50 cm to force the model. We selected this depth based on analyzing GPP deviations from its mean as a function of dryness (Fig. S5), which we will also mention in the manuscript.

  In regards to your second question, ψ_s is the root zone average soil moisture. We will update Sect. 2.1-2.5 to clearly reflect this definition.

- Regarding the calibration of the dynamic β model, to my understanding, the results from the full complexity PHM was used to derive the dependence of the stress factor to Tww and ψs. As this would not be the case with existing TBMs, can the authors suggest a general procedure on how a generic calibration could be achieved for a "general-purpose" dynamic β model?

  BPS: We are currently working on a follow-up manuscript to validate the simple parametrization for the dynamic β and to relate its parameters to key hydraulic traits. In the updated manuscript, we will emphasize that the dynamic β has potential to be a parsimonious alternative to PHMs and that we are pursuing future work on the topic.

  Currently, our dynamic β formulation can provide less computational complexity than a PHM; however, we do not yet know if the simple linear parameter relationships (Fig. S2) will hold for sites other than US-Me2. A user could attempt calibration with our model structure as is, but further work must be done to ensure its general applicability. We will discuss these points further in the revision.

- One aspect worth discussing is the use of capacitance within a plant hydraulic model. I would encourage the authors to expand their discussion regarding this point, as several TBMs now adopt a resistor/capacitor approximation when formulating their plant hydraulic modules.

  BPS: Thank you for pointing this out. In the updated manuscript, we will discuss the potential effects of incorporating plant capacitance in Sect. 4. We expect plant capacitance to cause hysteresis in the PHM transpiration downregulation patterns, which would be very difficult for existing β formulations to capture. However, we expect for supply-limited systems that water potential will equilibrate quickly (due to high conductances) and the hysteretic effects may be negligible. Therefore, we think that adding capacitance would: 1) increase the divergence between PHMs and β for transport-limited systems and 2) have little impact in supply-limited systems.

- I agree with reviewer 1 regarding the interpretation of the results. The behaviour of β models limiting particularly photosynthetic rates (or in some cases Vcmax), might have a different behaviour that the reported. That would be worth discussing further.

  BPS: This is an interesting point. We will update Sect. 2.5 to discuss the debate over whether to apply β directly to stomatal conductance and/or to non-stomatal limitations (as you have mentioned). We will emphasize that our main conclusions about the differences in β and PHMs will not change as long as the downregulation factors for β ($\beta(\psi_s)$; Eq. 15-16) and PHMs ($f(\psi_l)$; Eq. 3,8) are applied consistently to the same variables in the downregulation scheme. For example, if both $\beta(\psi_s)$ and $f(\psi_l)$ were applied to V_{cmax}, the coupling between atmospheric moisture demand and soil water stress is still expected to disappear as conductance becomes infinite, because ψ_l approaches ψ_s. Therefore, PHMs would still approach β. The only changes may be the magnitude of differences in the LSM analysis for a transport-limited site. These issues will be discussed thoroughly in the revision.

Minor comments:

- Line 101, 98: has instead of is?

  BPS: Since I am defining the terms, I think "is" is actually the appropriate form.

- Line 133: Neutral atmosphere, instead of "negligible atmospheric stability"

  BPS: We will change in the updated manuscript.

- Line 137: “and codes will be made available online with acceptance of this manuscript”. Not a necessary statement in the manuscript. The code will appear upon acceptance.

  BPS: We will remove in the updated manuscript.

- It would be nice to keep consistent units for transpiration and conductance terms throughout the manuscript.

  BPS: I think this comment is referring to Equation 9 and stomatal conductance in terms of moles/m$^{\wedge 2}$/s. Based on a comment from reviewer 3, we will update all units to ensure consistency between minimalist and complex formulations. The changes to units will be as follows:

  - **Change transpiration fluxes from W/m^2 to mm/day.**
  - **Change all supply conductances (g_{sp}, g_{sx}, and g_{xl}) to mm/day/MPa in both the minimalist and complex analysis.**
  - **Update the stomatal conductance (g_s) units to mol air/m^2/s and provide vapor pressure differences in units mol H_2O/mol air. Then, we will include the conversion factor from molar flux (mol H_2O/m^2/s) to volume flux (mm/day) for clarity.**