Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
https://doi.org/10.5194/gmd-2022-17-RC2, 2022

Comment on gmd-2022-17

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Referee comment on "SurEau-Ecos v2.0: a trait-based plant hydraulics model for simulations of plant water status and drought-induced mortality at the ecosystem level" by Julien Ruffault et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-17-RC2, 2022

The study presents a new trait-based plant hydraulics model that can scale tissue-level hydrodynamics to stand-level water use and hydraulic risks (SurEau-Ecos). The new model represents four plant water pools (leaf+stem X apoplasmic+symplasmic) and three soil water pools. The manuscript reports explorations of different numerical resolutions (explicit, implicit, semi-explicit) and recommends a time-step around 1min using implicit/semi-implicit methods. The difference between the SurEau-Ecos and SurEau, a more detailed individual-level version, is shown to be small. Sensitivity analysis suggests stand-level parameters determine the time to hydraulic failure while hydraulic traits such as psi_50 for leaves contribute more to the drought-driven mortality risk. Finally, predictions from SurEau-Ecos at the regional scale are cross-validated with species distributions for two temperate species in France.

Overall, I really enjoy reading the manuscript partly because the equations and model structures are presented in a clear way, starting from the governing equations and then diving into different components. I appreciate the analysis of numerical schemes, which we also struggled with when developing the plant hydraulics in ED2 (and thanks for showing the biases of our semi-implicit method in a more robust way).

Meanwhile, I feel the manuscript can become more useful to the community if expanding discussions on the "necessary/optimal" complexity in plant hydraulics at ecosystem scales. In addition, lack of competition and succession can really limit the utility of the model at longer timescales in my opinion. Here are my comments following the order of the manuscript

Line 95 - Fig. 1 It is great to see energy balance of plant tissues is considered since leaf temperature can be quite a few degrees different from air temperature during drought. I was wondering whether leaf temperature dynamics have been evaluated? My experience with ED2-hydro is that it tends to overestimate leaf temperature during middays (compared with thermal camera data), which exacerbated water stress, led to more stomatal closure, less transpiration, then even higher leaf temperature.

Additional comment on Fig.1. I like the idea to separate apoplasmic and symplasmic water pools, which is more realistic in terms of physiology. However, is it necessary (or in what scenarios is it necessary), and what is the additional computational cost associated with the separation? From Line 388-395, it seems the model itself is not sensitive of apoplasmic water storage. I guess the advantage is to better assimilate plant hydraulic trait measurements while I wonder what would the biases be if ignoring these water pools.

Line 138, I am curious about the hydraulic redistribution part. I guess it happens when psi_soil is lower than psi_sapo? We found that enabling water out-flow from root to soil and using the same soil-root hydraulic conductance formulation can lead to too much hydraulic redistribution that is homogenizing soil water across vertical layers. Some studies suggest that soil-root conductance can be higher than root-soil conductance (Prieto et al. 2012).

Prieto, I., C. Armas, and F. I. Pugnaire. 2012. Water release through plant roots: new insights into its consequences at the plant and ecosystem level. New Phytologist 193:830–841.

Line 188. Why three layers? Why not making it adaptive based on total soil depth?

Line 320, Section 2.6 For numerical schemes, have you tried Runge-Kutta? In ED2, we used the the fourth order RK method for integrating various PDEs, which seems to give a good balance of accuracy and computational cost.

Line 520 Fig. 4. I am curious why osmotic potential plays such a minor role in all these metrics. Is it only used to convert RWC and Q? osmotic potential can have large inter- and intra- species variations (even large diurnal changes) that can change leaf turgor loss point, which is tightly associated with psi_gs_50. From this figure, it seems psi_gs50 and pi_0 are decoupled?

In addition, it is interesting to see that cuticular conductance is very important to determine survival as well. I also found the strong influence of cuticular gs on plant hydrodynamics in ED2-hydro. Are there good data sets to constrain the variations in the parameter? In general, it can be rather useful to point out which parameters can be readily acquired/measured.

Line 540, typo, "the leaf and leaf ", should be "the leaf and stem"

Line 595. Fig.5, the Quercus ilex result is very hard to interpret with little explanations in the text. Could it because the lack of competition in the model?

Line 615-620, treating LAImax as a model parameter indicates the model only considers mature forest that has reached LAImax. This might be fine for qualitative assessment of mortality risk. However, shouldn't forests reach a new equilibrium with lower LAImax under drier conditions? (i.e. LAImax should change over time) For example, in Fig. 5, how would the mortality risk change if the forests are thinner with lower LAImax?

Tab. B1, symplasm pi_0 for leaf should be -2.1

Fig. B2-B3. Given the computational cost vary so much with longer time step, I wonder how much the difference matters at the regional scale between 1min and 10min... How worrisome we should be if models take a semi-implicit scheme with a somewhat long time-step