Response to Referee #1's Comments

Dear authors,

Dear editor,

Thank you for letting me referee this very interesting manuscript. After careful consideration, I must unfortunately recommend **rejection** of the manuscript.

Dear reviewer,

We sincerely thank you for your thoughtful and constructive comments, which have greatly helped us to improve our manuscript. Your suggestions have been invaluable in clarifying the context of our study and enhancing its accessibility to a broader readership.

In response to your feedback, we have carefully revised the manuscript to address your concerns and incorporate your recommendations. We deeply appreciate your effort in reviewing our work and hope that the revised version meets the standards for publication in HESS.

Thank you again for your time and insightful comments.

Zengjing Song, on behalf of all the co-authors.

Summary

This manuscript by Song and colleagues presents an extension of the ecohydrological model STEMMUS-SCOPE that incorporates an improved representation of plant hydraulics into the model. Similar work has been presented in Simeone et al. (2018), where the authors incorporate a soil–plant–atmosphere continuum model into the ecohydrological model Ech2o to study water stress in pine trees (the editor can verify that I have no affiliation to the paper). The topic remains of interest to the ecohydrological community and the readership of HESS.

The authors show that including more detailed plant hydraulics into STEMMUS-SCOPE increases model accuracy with regard to several observation data collected at the intermediate scale. The manuscript is sufficiently well written, however, I had some difficulties following the methodology section, specifically Section 2.4, that I will comment on below. The figures that have been included into the manuscript are clear and relevant.

In my opinion, the manuscript could be enhanced by further improving the discussion section to address some remaining open questions. I will list my major concerns about this below, addressing some of these may require extensive work. Thus, I recommend **rejecting** the manuscript and inviting a re-submission once the issues below have been clarified.

Alternatively, a version of this manuscript that focuses more on the technical aspects of the model might be suitable for *Geoscientific Model Development*.

References

Simeone, C. et al. (2018), Coupled ecohydrology and plant hydraulics modeling predicts ponderosa pine seedling mortality and lower treeline in the US Northern Rocky Mountains, *New Phytologist*, 221:1814–1830. doi:10.1111/nph.15499

Thank you for your interest in this research topic and for your careful reading of our manuscript. In this work, we integrated the plant hydraulics pathway into a soil-plant-atmosphere continuum model (STEMMUS-SCOPE) to investigate the impacts of water stress on carbon and energy fluxes, to be specific, the response of plants to drought over the karst region.

We also appreciate your reference to the work of Simeone et al. (2018). Their study, which explores the impacts of water stress on treelines in the Rocky Mountain region and the effects of hydraulic failure-induced tree mortality, was both insightful and a pleasure to read. We agree that their findings are closely related to our research topic and have further inspired us to pursue our study. While Simeone et al. (2018) focused on the dynamics of hydraulic failure and tree mortality, our study addresses a complementary yet distinct question: to what extent does the incorporation of an explicit plant hydraulic pathway enhance the understanding of ecosystem fluxes of water, energy, and carbon? This question is pivotal for evaluating the climate resilience of ecosystem functioning, a consideration that is equally critical to the assessment of hydraulic failure and tree mortality. These processes are intricately coupled and coordinated; however, the mechanisms underlying this coordination remain insufficiently characterized. Our manuscript seeks to elucidate these interdependencies, offering novel insights into the integrative functioning of plant hydraulics within ecosystems.

Major comments

[1] STEMMUS-SCOPE-PHS presentation could be improved.

[1.1] Section 2.4 starts with the discussion of calculating the stomatal conductance, which depends on the calculation of net carbon assimilation A_n. It remains unclear how A_n is calculated until 2.4.3, where it is revealed that Farquhar's approach is used. I think it would be better to mention this directly where A_n is introduced (Eq. 1, Sec. 2.4.1).

Thank you very much for your constructive suggestion. The calculation of A_n has been added in Section 2.4.1 accordingly, revised as follows:

2.4.1 Stomatal conductance scheme and photosynthesis

In STEMMUS-SCOPE-PHS, a semi-empirical optimal stomatal conductance model (Medlyn et al., 2011) is employed to represent the potential influence of the increasing vapor pressure deficit on stomatal regulation,

$$g_s = g_0 + a_{c2w} \cdot \left(1 + \frac{g_1}{\sqrt{D}}\right)\left(\frac{A_n \cdot\ ppm2bar}{C_a}\right) \tag{R1}$$

where g_s *is stomatal conductance (*$mol\,m^{-2}s^{-1}$*) for water vapor,* g_0 *is the minimum stomatal conductance (*$mol\,m^{-2}s^{-1}$*),* g_1 *is the slope of stomatal conductance (*$hPa^{0.5}$*),* D *is water vapor pressure deficit (*hPa*),* C_a *is the* CO_2 *concentration at the leaf surface (*bar*). The* a_{c2w} *equals 1.6, which is used to convert the conductance of* CO_2 *to that of water vapor.* A_n *is the net carbon assimilation rate (*$\mu mol\,m^{-2}s^{-1}$*), ppm2bar converts the units from* $\mu mol\,mol^{-1}$ *to bar.*

The A_n *is calculated as the minimum of two processes for C3 plants, and the minimum of three processes for C4 plants (Wang et al., 2021):*

$$A_n = \begin{cases} min(V_c, V_e), & for\ C3\ plants \\ min(V_c, V_e, V_s), & for\ C4\ plants \end{cases}, \tag{R2}$$

where V_c, V_e, V_s *are carboxylation rate limited by Ribulose biphosphate-carboxylase-oxygenase activity (Rubisco-limited,* $\mu mol\,m^{-2}s^{-1}$*), Ribulose1-5 bisphosphate regeneration rate (RuBP-limited,* $\mu mol\,m^{-2}s^{-1}$*), and intercellular* CO_2 *partial pressure (*$\mu mol\,m^{-2}s^{-1}$*), respectively.*

The water stress effect on photosynthesis is represented as the product of the leaf water potential-based water stress factor (phwsf) and the maximum carboxylation rate under well-watered conditions (V_{cmax}*,* $\mu mol\,m^{-2}s^{-1}$*):*

$$Vc = Vcmax \times phwsf \tag{R3}$$

For C3 plants (Bayat et al., 2018),

$$V_{cmax} = V_{cmax,25} \cdot \frac{C_i - \Gamma^*}{C_i + K_c\left(1 + \frac{O_i}{K_o}\right)}, \tag{R4}$$

where $V_{cmax,25}$ *is the maximum carboxylation capacity at 25 °C (*$\mu molm^{-2}s^{-1}$*),* C_i *and* O_i *are the intercellular* CO_2 *and* O_2 *partial pressure (bar),* Γ^* *is* CO_2 *compensation point (bar),* K_c

(3.5×10^{-4} bar) and K_o (4.5×10^{-4} bar) are the Michaelis-Menten constant for CO₂ and O₂, respectively.

$$V_e = J \cdot effcon \cdot \frac{C_i - \Gamma^*}{C_i + 2\Gamma^*}, \tag{R5}$$

where J is the electron transport rate ($\mu mol\ m^{-2} s^{-1}$), the effcon is a constant, and the value of it is $\frac{1}{5}$ (or $\frac{1}{4}$) depended on ATP (or NADPH) limitation for photosynthesis (Bonan, 2019). In this research, effcon equals $\frac{1}{5}$.

For C4 plants (Collatz et al., 1992),

$$V_{cmax} = V_{cmax,25}, \tag{R6}$$

$$V_e = \frac{J}{6}, \tag{R7}$$

$$V_s = K_{pepcase} * C_i, \tag{R8}$$

where $K_{pepcase}$ is a pseudo-first-order rate constant for Phosphoenolpyruvate (PEP) carboxylase ($\mu mol\ m^{-2} s^{-1} bar^{-1}$) (Collatz et al., 1992).

[1.2] It is unclear to me what variable the model is solving for.

STEMMUS-SCOPE-PHS solves the water potential of root ($\psi_{root,i}$), stem (ψ_{stem}) and leaf (ψ_{leaf}), which are further used to calculate the plant water stress factor ($phwsf_{ED2}$ or $phwsf_{CLM}$).

In STEMMUS-SCOPE-PHS, the root water potential at the ith layer is calculated as:

$$\psi_{root,i} = \psi_{soil,i} - z_i - \frac{q_{soil-root,i}}{k_{soil-root,i}}, \tag{R9}$$

where $\psi_{soil,i}$ (m) is soil water potential at the ith layer, z_i (m) means the depth of ith soil layer, $q_{soil-root,i}$ (m s^{-1}) is the water fluxes from soil to root at the ith layer, $k_{soil-root,i}$ (s^{-1}) is soil to root hydraulic conductance.

The stem water potential is calculated as:

$$\psi_{stem} = \psi_{root} - h - \frac{q_{root-stem}}{k_{root-stem} \times SAI}, \tag{R10}$$

where h (m) is the height of the canopy that is equal to gravitational potential, $q_{root-stem}$ (m s^{-1}) is water flux from root to stem, $k_{root-stem}$ (s^{-1}) is hydraulic conductance from root to stem. $SAI\ (m^2m^{-2})$ is stem area index.

The leaf water potential is calculated as:

$$\psi_{leaf} = \psi_{stem} - \frac{q_{stem-leaf}}{k_{stem-leaf} \times LAI}, \tag{R11}$$

where $q_{stem-leaf}$ (m s^{-1}) is water flux from stem to leaf, $k_{stem-leaf}$ (s^{-1}) is hydraulic conductance from stem to leaf, LAI (m^2 m^{-2}) is leaf area index.

Once the leaf water potential is available, the plant water stress factor can be calculated based on the scheme in ED2 model as:

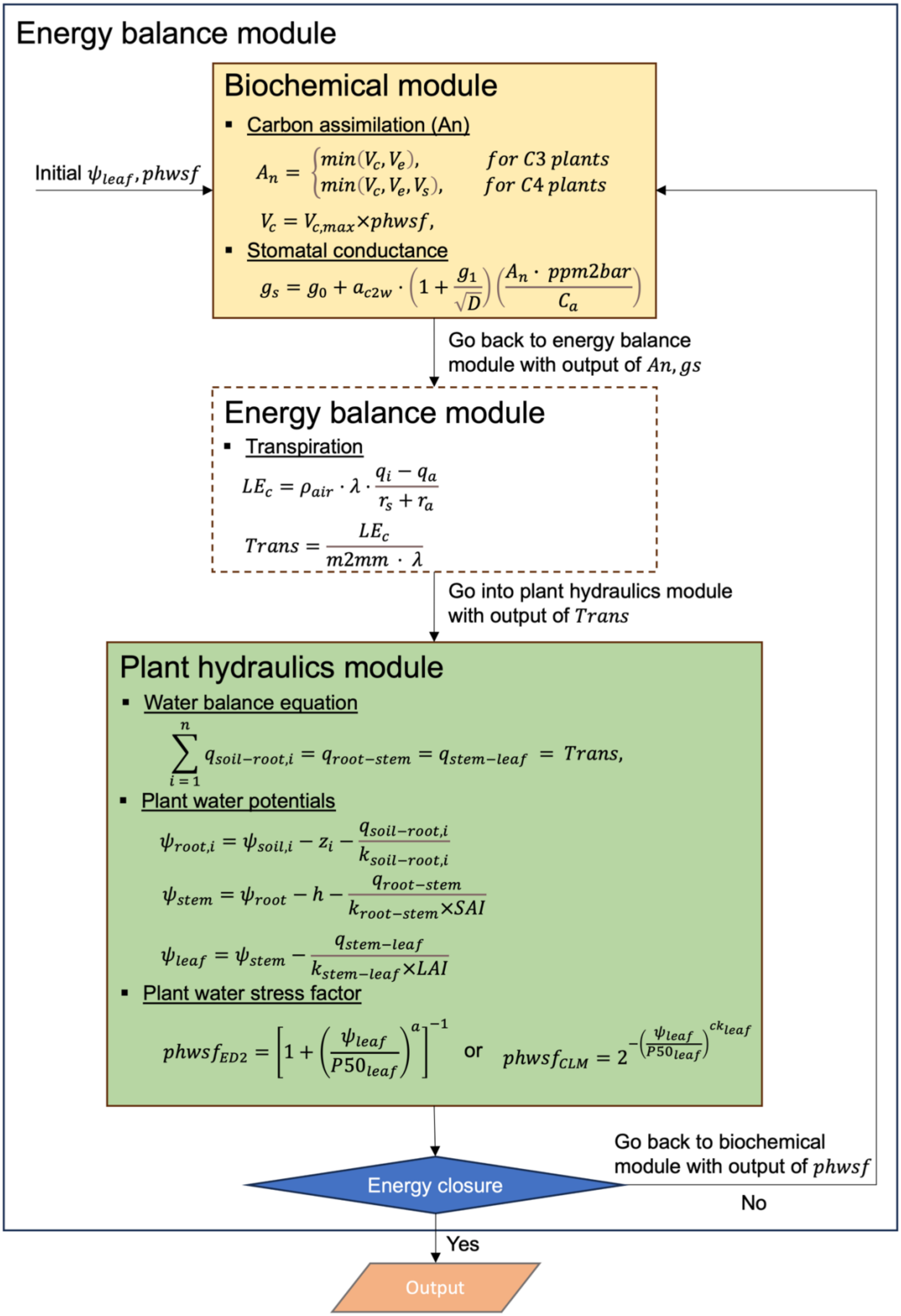
$$phwsf_{ED2} = \left[1 + \left(\frac{\psi_{leaf}}{P50_{leaf}}\right)^{a}\right]^{-1}, \tag{R12}$$

or based on the scheme in CLM as:

$$phwsf_{CLM} = 2^{-\left(\frac{\psi_{leaf}}{P50_{leaf}}\right)^{ck_{leaf}}}, \tag{R13}$$

where $P50_{leaf}$ (m) is the water potential at the 50% hydraulic conductance loss and a (or ck_{leaf}) is a shape parameter.

To clarify the flamework of the STEMMUS-SCOPE-PHS, a flowchart (Fig. R1) has been added accordingly.



Biochemical module

- Carbon assimilation (An)

$$A_n = \begin{cases} min(V_c, V_e), & for\ C3\ plants \\ min(V_c, V_e, V_s), & for\ C4\ plants \end{cases}$$

$$V_c = V_{c,max} \times phwsf,$$

- Stomatal conductance

$$g_s = g_0 + a_{c2w} \cdot \left(1 + \frac{g_1}{\sqrt{D}}\right)\left(\frac{A_n \cdot ppm2bar}{C_a}\right)$$

Energy balance module

- Transpiration

$$LE_c = \rho_{air} \cdot \lambda \cdot \frac{q_i - q_a}{r_s + r_a}$$

$$Trans = \frac{LE_c}{m2mm \cdot \lambda}$$

Plant hydraulics module

- Water balance equation

$$\sum_{i=1}^{n} q_{soil-root,i} = q_{root-stem} = q_{stem-leaf} = Trans,$$

- Plant water potentials

$$\psi_{root,i} = \psi_{soil,i} - z_i - \frac{q_{soil-root,i}}{k_{soil-root,i}}$$

$$\psi_{stem} = \psi_{root} - h - \frac{q_{root-stem}}{k_{root-stem} \times SAI}$$

$$\psi_{leaf} = \psi_{stem} - \frac{q_{stem-leaf}}{k_{stem-leaf} \times LAI}$$

- Plant water stress factor

$$phwsf_{ED2} = \left[1 + \left(\frac{\psi_{leaf}}{P50_{leaf}}\right)^{a}\right]^{-1} \quad \text{or} \quad phwsf_{CLM} = 2^{-\left(\frac{\psi_{leaf}}{P50_{leaf}}\right)^{ck_{leaf}}}$$

Fig. R1 Framework of the STEMMUS-SCOPE-PHS model.

[1.2.1] Starting from Sec. 2.4.1, I initially assumed that the model computes transpiration (*T*) as a function of the water potential gradients. It then surprised me that *T* is calculated on the basis of an energy balance in Eq. 6 as *T = LE/λ*? Doesn't make this the whole plant hydraulics redundant? Or are water potentials fitted to the transpiration through Eqs. 2–5?

We acknowledge the reviewer's comments on this point and appreciate the opportunity to elaborate. Transpiration (or evaporation) is a fundamental component of the coupled water, energy, and carbon cycles within the soil-plant system. In our previous study (Wang et al., 2021, GMD), the STEMMUS-SCOPE model employed a hydraulic resistance scheme to constrain Vcmax using a water stress factor, thereby enhancing the characterization of ecosystem responses to drought. This water stress factor was formulated as a function of root-zone water content and root length distribution.

From that study, we identified leaf water potential as a critical regulator of photosynthetic processes, evidenced by its linear correlation with solar-induced fluorescence (SIF). This finding underscored the pivotal role of leaf water potential in mediating the integrated fluxes of water, energy, and carbon.

Building on these insights, the present study explicitly incorporates the plant hydraulic pathway to facilitate the coordination of leaf-level processes, including transpiration, with water potentials across the soil-plant continuum—encompassing the leaf, stem, root, and soil. Moving beyond the hydraulic resistance scheme, we now prognostically compute water potentials throughout the soil-plant system. Consequently, the water stress factor has been reformulated based on the model-simulated leaf water potential, providing a more physiologically realistic mechanism for evaluating ecosystem drought responses.

The equations below quantify the role of leaf water potential in the aforementioned intricate and interconnected processes:

The latent heat fluxes, LE (specifically, actual canopy latent heat fluxes, LE_c), is calculated as (van der Tol et al., 2009):

$$LE_c = \rho_{air} \cdot \lambda \cdot \frac{q_i - q_a}{r_s + r_a}, \tag{R14}$$

where ρ_{air} (kg m^{-3}) is the specific mass of air, λ (J kg^{-1}) is the latent heat of vaporization of water, q_i(-) and q_a (-) are intercellular and atmospheric absolute humidity, r_s ($s\ m^{-1}$) and r_a ($s\ m^{-1}$) are stomatal and aerodynamics resistance, respectively.

$$r_s = \frac{1}{g_s} \cdot \frac{\rho_{air}}{M_{air}}, \tag{R15}$$

where M_{air} (kg mol^{-1}) is the molecular mass of dry air. g_s $(mol\, m^{-2} s^{-1})$, is calculated by equation (R1).

Reference:

Wang, Y., Zeng, Y., Yu, L., Yang, P., Van der Tol, C., Yu, Q., Lü, X., Cai, H., and Su, Z.: Integrated modeling of canopy photosynthesis, fluorescence, and the transfer of energy, mass, and momentum in the soil–plant–atmosphere continuum (STEMMUS–SCOPE v1.0.0), Geosci. Model Dev., 14, 1379–1407, https://doi.org/10.5194/gmd-14-1379-2021, 2021.

On a side note: Eq. 6 gives the unit mol s-1 m-2, which is fine, but is inconsistent with Eq. 2, where fluxes are expressed in m/s. It seems a transformation coefficient is missing here.

Thank you for your comment, the unit of latent heat of vaporization (λ) in STEMMUS-SCOPE-PHS is in [J kg^{-1}] which is a typo in the draft. Eq.6 has been revised as:

$$Trans = \frac{LE_c}{m2mm \cdot \lambda}, \tag{$R16, Eq.6\ in\ the\ main\ text$}$$

where LE_c (W m^{-2}) is the canopy latent heat flux, λ (J kg^{-1}) is the latent heat of vaporization of water. The factor m2mm (=1000) converts the unit from mm s^{-1} to m s^{-1}.

[1.2.2] The stomatal conductance g_s from Eq. 1 does not appears neither in the following equations nor in the appendix. This might be related to my comment 1.2.1 above.

Thank you for your comment. The stomatal conductance was calculated based on net carbon assimilation (A_n), atmospheric vapor pressure deficit (D) and CO$_2$ concentration at the leaf surface (C_a) as mentioned in Eq. R1. The stomatal conductance was used to calculate the actual canopy latent heat flux (LE_c) as described above (Eqs. R14-15 and Fig. R1).

[2] PSY-1 measurements need to be clarified.

This relates to Sec. 2.2. From my perspective, the PSY-1 measurements are the only direct observations of plant hydraulics and all other measurement data such as GPP, SIF, and PAR are proxies to it. Therefore, it is very important to me to understand how many trees were sampled.

From the text and Fig. 1, it reads as if only a single tree has been instrumented for two months? If so, this feels quite inadequate and there needs to be some justification for the choice of tree and the measurement period. Similarly, at how many locations were soil sensors installed? The uncertainty introduced to the results and model evaluation might be significant. This is also relevant to the poor match of model results and observations shown in Fig. 7. I know that it might be unfair to criticise the lack of data in this study, because collecting data is time intensive. Perhaps the model implementation needs to be verified in a more heavily monitored site before moving to the Hutoucun site.

As explained in our response to point [1.2.1], this manuscript focuses on advancing the understanding of ecosystem drought responses, with particular emphasis on the role of leaf water potential in regulating the integrated fluxes of water, energy, and carbon. Our ultimate aim is to enhance the understanding of ecosystem functioning (e.g., through the monitoring and modeling of ecosystem fluxes) and to facilitate mechanistic investigations into ecosystem climate resilience.

The reviewer noted that "… the PSY-1 measurements are the only direct observations of plant hydraulics, and all other measurement data such as GPP, SIF, and PAR are proxies to it." However, we contend that the inverse is also true: measurements of water potentials in the soil, stem, and leaf can likewise be considered proxies for water, energy, and carbon fluxes, including SIF. This is because these variables are integral components of the coupled soil-plant processes. In this context, our current work focuses on enhancing the STEMMUS-SCOPE model to better represent the coordinated processes between plant hydraulics and photosynthesis, thereby improving its connection to ecosystem fluxes and SIF.

The Hutoucun site serves as a testbed to examine and validate whether our model enhances the process-level understanding of ecosystem drought responses. This site provides a complementary dataset collected over a Osmanthus fragrans (Sweet olive) plantation in a karst region. While we are eager to test the model on datasets from other regions, species, or plant functional types, the availability of such datasets is currently limited. Setting up a field site is highly resource-intensive—for instance, establishing the Hutoucun site required an investment of approximately €160,000, excluding ongoing maintenance costs.

We greatly value community efforts, such as the FluxNet initiative, which provides access to data from 170 sites and supports collaborative activities like PLUMBER2 (Abramowitz et al., 2024). However, it is worth noting that plant hydraulics and water potential data are not yet available for FluxNet sites. To address this gap, the community has initiated PSINet, a collaborative effort to collect plant hydraulics data, in which we are actively involved.

We acknowledge that certain experimental details were not sufficiently described in the original manuscript. We have since updated the relevant sections as detailed below:

At the Hutoucun site, two stem water potential sensors (PSY-1, ICT, Australia) were installed on two trees near the flux tower, one approximately 5 meters to the southeast and the other about 6 meters to the northeast.

As shown in Fig. R2, two sensors installed on two trees showed similar time series dynamics, indicating that the sensors effectively captured the decreasing trend of stem water potential over time.

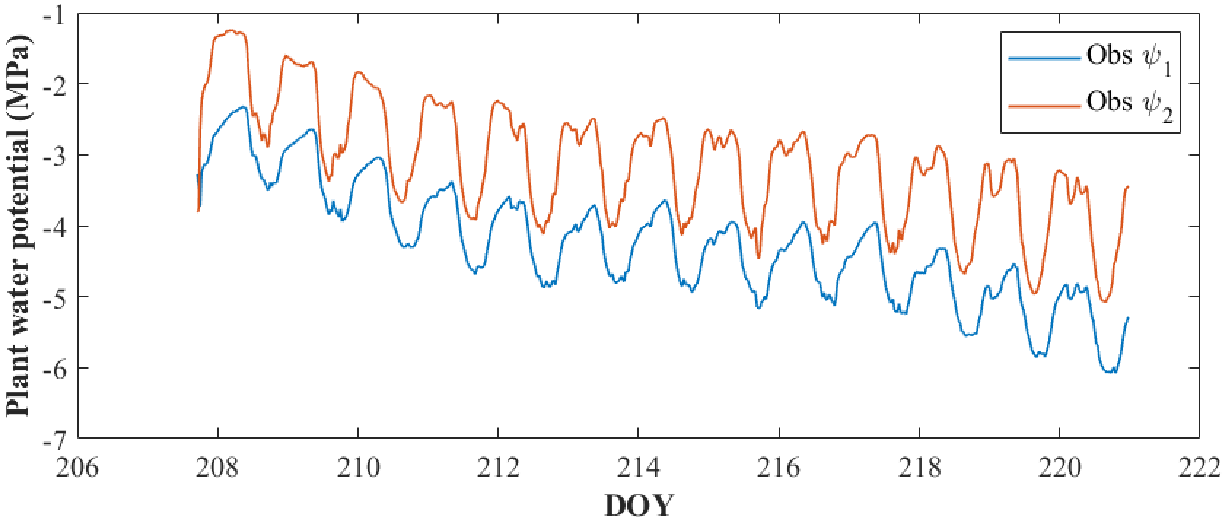


Fig. R2 Two observations of stem water potential at the Hutoucun site.

At the Hutoucun site, soil temperature and soil moisture sensors were installed at a single location about 1.5 m south of the flux tower. Specifically, they were installed vertically at seven depths of 2cm, 5cm, 10cm, 20cm, 40cm, 60cm, and 80 cm. The comparison of simulated and observed soil moisture is shown in Supplementary Fig. S2.

Reference:

Abramowitz, G., Ukkola, A., Hobeichi, S., Cranko Page, J., Lipson, M., De Kauwe, M., Green, S., Brenner, C., Frame, J., Nearing, G., Clark, M., Best, M., Anthoni, P., Arduini, G., Boussetta, S., Caldararu, S., Cho, K., Cuntz, M., Fairbairn, D., Ferguson, C., Kim, H., Kim, Y., Knauer, J., Lawrence, D., Luo, X., Malyshev, S., Nitta, T., Ogee, J., Oleson, K., Ottlé, C., Peylin, P., de Rosnay, P., Rumbold, H., Su, B., Vuichard, N., Walker, A., Wang-Faivre, X., Wang, Y., and Zeng, Y.: On the predictability of turbulent fluxes from land: PLUMBER2 MIP experimental description and preliminary results, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-3084, 2024.

[3] Discussion should be improved.

[3.1] Disagreement of plant water potential is quite severe.

Looking at Fig. 7, the disagreement between simulated and observed plant water potential is quite severe. In the discussion, the authors state that diurnal dynamics have been captured. I must disagree. Even if we neglect absolute values, the simulated plant water potential both in leaf and root is much more erratic than the observed one. Further, observed diurnal dynamics on DOYs 208, 211, and 212 clearly follow different dynamics than the simulated ones. This implies that the *in silico* plant is showcasing a much more anisohydric behaviour than the *in situ* one. While intermediate scale observations have been matched quite well, this implies that the plant hydraulics and its pathway may not have been captured properly by the model. This has implications on the conclusions drawn in this study.

Thanks for your comment. To assess the model's ability to capture diurnal dynamics and to remove biases caused by instruments and different trees, we use the detrend function in Matlab to remove the linear trend of simulated and observed stem water potential (Fig. R3). The results show that the simulated stem water potential decreases earlier than the observed stem water potential in the morning, as well as increases earlier than the observed stem water potential in the afternoon. This discrepancy can be attributed to water storage in the plant, which is not included in the current version of our model, the plant water storage provides a water buffer to prevent a quick decrease of stem water potential in the morning, and a later increase in the afternoon because the buffer needs to be filled first. The drastic changes of simulated stem water potential are because the hydraulic conductance is sensitive to changes in water potential.

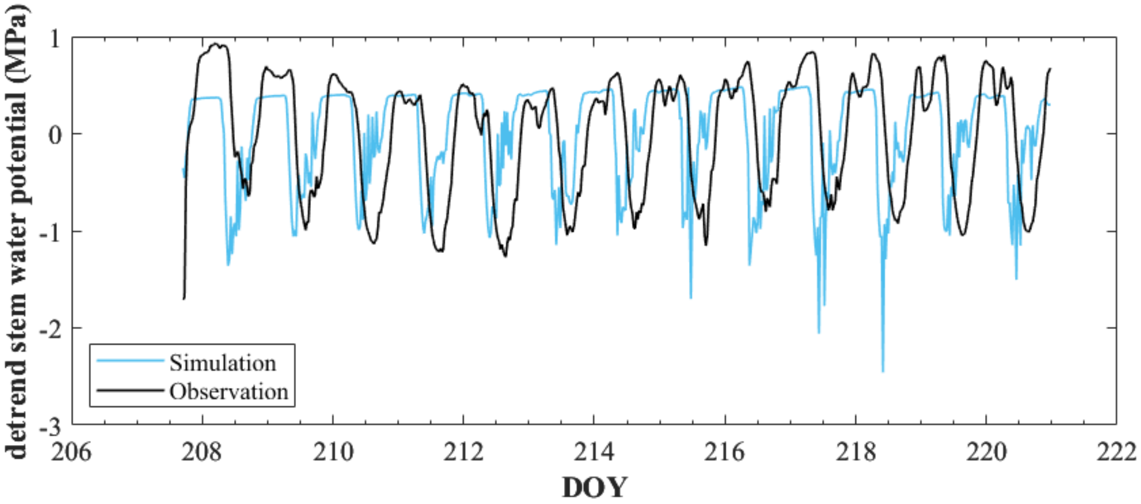


Fig. R3 Comparison between detrend simulated and observed stem water potential.

The authors demonstrate that including plant hydraulics into the model improves these site scale observations. This might be related to the additional degrees of freedom that are introduced into the model that allow for a better fit. It is then not clear to me, whether the model improvement is actually for the right reason or simply because of the expanded parameter space, especially considering that the plant water potential is not matched correctly. Perhaps the plant hydraulics module could be better calibrated? Because the model description is not entirely clear to me, I cannot draw any further conclusions on this point.

The model description has been modified accordingly, see our responses to 1.1, and 1.2. Integrating plant hydraulics module enable us to calculate root, stem and leaf water potentials, as well as plant water stress factor. These variables cannot be calculated without considering the plant hydraulics.

[3.2] Data scarcity hinders further discussions of any plant responses-related issue

Unfortunately, the single data point that I commented on in Sec. 2 hinders any deeper discussion of any plant responses-related issue and any interpretation of model results. In Sec. 4.3, the authors suggest that plant water storage might be a reason for the poor agreement. But at this point, any other reasoning, including measurement error, might be equally valid.

Please see our response to point [2].

[3.3] Main questions of the manuscript are left unanswered

The issue of how these plants respond to water stress is not discussed in depth in the manuscript. Instead, only model performance with regard to observations are compared. It would improve the manuscript if additional insights that have been gained through this modelling exercise were discussed.

Thank you for your comment. We chose a water-limited period (DOY208-210) when the observation of stem water potential is available to analyse and discuss the plant's response to water stress. We will add the following paragraph as Section 4.4.

> *4.4 Plant's response to water stress*
>
> *The dynamics of latent heat flux (LE), observed air temperature (Tair), shortwave downward radiation (SWdown), actual vapor pressure (ea), saturated vapor pressure (es), vapor pressure deficit (VPD) are shown in Fig. R4. Since saturated vapor pressure (es) is calculated by air temperature (Tair), they exhibit similar dynamics. The ea decreases following a reduction in*

latent heat flux, which is accompanied with an increase in VPD. It indicates that SWdown drives transpiration and evaporation, and because transpiration is the process by which plants release water into the atmosphere through their stomata, it results in an increase in ea. This is an important insight in settling the cause-effect debate if the VPD is the cause of transpiration or its effect.

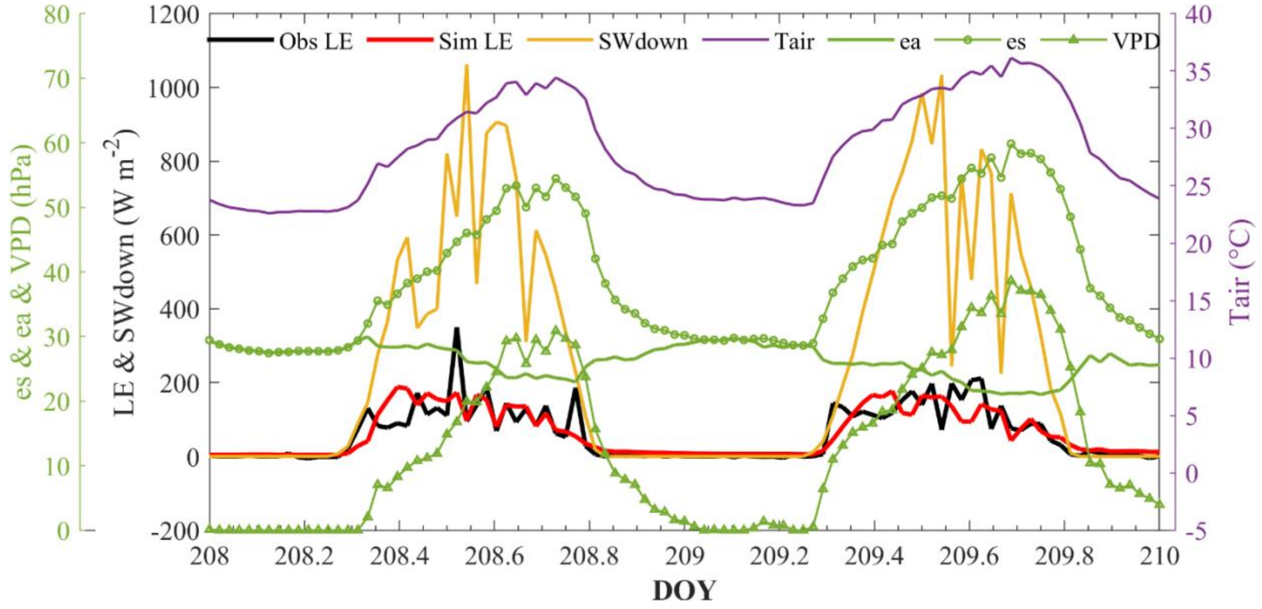


Fig. R4 The dynamics of observed and simulated latent heat flux (Obs LE and Sim LE), observed shortwave downward radiation (SWdown), observed air temperature (Tair). The saturated vapor pressure (es) is calculated based on Tair $es = 6.107 * 10^{\frac{Tair*7.5}{237.3+Tair}}$*, and the actual vapor pressure (ea) is calculated from observed relative humidity (RH) and es,* $ea = es * RH$*. The vapor pressure deficit* $VPD = es - ea$*.*

Fig. R4 and Fig. R5 indicate that transpiration decreases leaf water potential, resulting in an increase of water stress (a lower value of plant hydraulics water stress factor (phwsf)). As water is lost through stomata, the stomata regulate their opening to maximize CO_2 *absorption and minimize the water loss. In the afternoon, stomata partially closed, reducing water loss, which leads to lower GPP and a gradual increasing leaf water potential compared to the morning. In addition, the root water uptake replenishes the water within the plant, contributing to an increase in leaf water potential during the nighttime. This study suggests that integrating plant hydraulics into STEMMUS-SCOPE enhances the understanding of ecosystem carbon, water and energy fluxes, and facilitates mechanistic investigations into ecosystem climate resilience.*

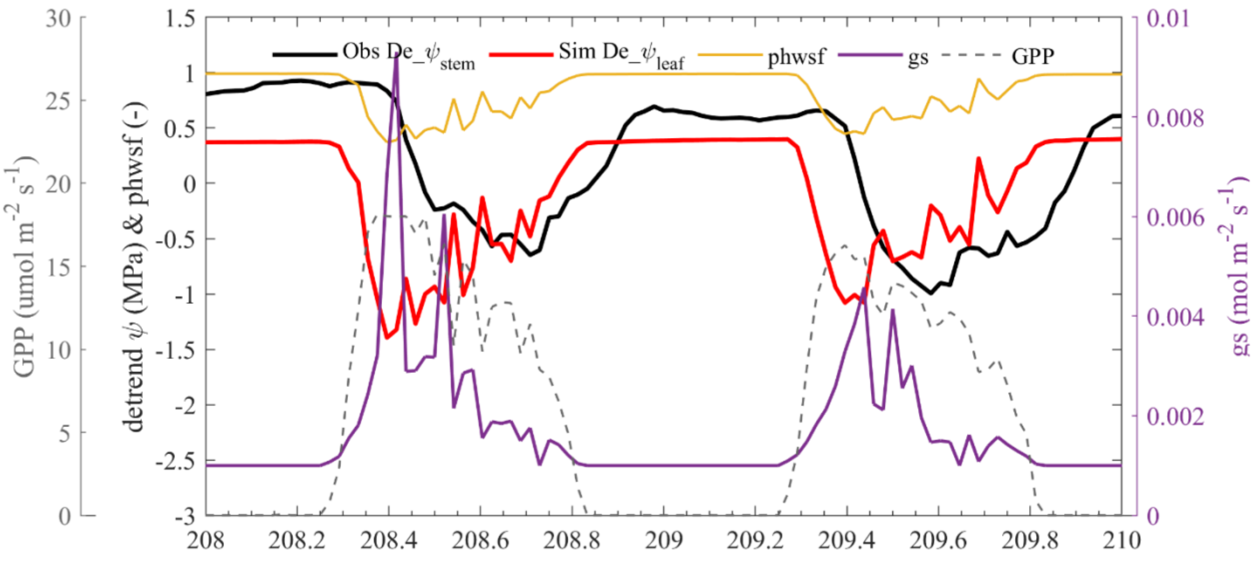


Fig. R5 The dynamics of observed and detrended stem water potential (Obs De_ψ_{stem}), simulated detrended leaf water potential (Sim De_ψ_{leaf}), simulated plant water stress factor (phwsf), simulated stomatal conductance (gs), and simulated gross primary productivity (GPP).

However, the issue in comment 3.1 is quite large and may make the claimed objectives of the paper on page 3, namely b) investigating the performance of the plant hydraulic model at a karst ecosystem, and c) answering how plants respond to drought from a perspective of plant hydraulics, not possible in this case study. Perhaps b) could be answered by saying the plant hydraulics model performs poorly on karst ecosystems. But because the reasons for the poor performance cannot be inferred, I don't think this is a good answer. The authors do not address the objective c) in the conclusions. As I reasoned above in my comment 3.1, I do not think this question can be answered on the basis of the current results. But I'm happy to be proven wrong.

Thank you for your comments. We've refined our research objective as "*Estimating whether incorporating plant hydraulic processes can improve the simulation of energy and carbon dynamics in a karst ecosystem*." As mentioned above, the simulated and observed stem water potential after detrending showed consistent dynamics, indicating the plant water potential can be used as an indicator of diurnal dynamics of water stress. And we had added Section 4.4 to analyze the response of plant to water stress. The aim in integrating plant hydraulics into STEMMUS-SCOPE model is to enhance the understanding of ecosystem functioning (e.g., through the monitoring and modelling of ecosystem fluxes) and to facilitate mechanistic investigations into ecosystem climate resilience, so that we can explain measurements from a mechanistic perspective. We consider that we have achieved this aim in our current work.

Abramowitz, G. et al., 2024. On the predictability of turbulent fluxes from land: PLUMBER2 MIP experimental description and preliminary results. EGUsphere, 2024: 1-47.

Bayat, B., van der Tol, C. and Verhoef, W., 2018. Integrating satellite optical and thermal infrared observations for improving daily ecosystem functioning estimations during a drought episode. Remote Sensing of Environment, 209: 375-394.

Collatz, G., Ribas-Carbo, M. and Berry, J., 1992. Coupled Photosynthesis-Stomatal Conductance Model for Leaves of C₄ Plants. Functional Plant Biology, 19(5): 519-538.

van der Tol, C., Verhoef, W., Timmermans, J., Verhoef, A. and Su, Z., 2009. An integrated model of soil-canopy spectral radiances, photosynthesis, fluorescence, temperature and energy balance. Biogeosciences, 6(12): 3109-3129.

Wang, Y. et al., 2021. Integrated modeling of canopy photosynthesis, fluorescence, and the transfer of energy, mass, and momentum in the soil–plant–atmosphere continuum (STEMMUS–SCOPE v1.0.0). Geoscientific Model Development, 14(3): 1379-1407.