Response to Referee #3's comments

Major comments

This is a scientifically largely solid paper, and it is good to see the hydraulic continuum implemented into Stemmus-Scope. I would have liked to have seen the new model tested for more sites, e.g. for the PLUMBER dataset. Instead, the authors decided to use quite an unusual site, with shallow soil and 'foggy' atmosphere. Is this the best approach to test the improved model? Does this in fact explain some of your findings?

We appreciate reviewer's comments here. The original STEMMUS-SCOPE model was tested for the PLUMBER2 dataset (Abramowitz et al., 2024). We completely agree with you that it would be great if the new model could be tested for the PLUMBER dataset as well. However, due to the limited availability of plant water potentials data, it is not possible to directly validate the key variables (root, stem or leaf water potential) in the newly developed plant hydraulics module (PHS). We are willing to test the STEMMUS-SCOPE-PHS for multiple sites when the plant water potential measurements are available.

The estimates of the LE and H fluxes are barely improved by the PHS, yet the GPP is. This seems strange? There is a disconnect here. This needs to be discussed and explained.

Thank you for your comments. GPP represent the canopy scale carbon assimilation, which is dominated by stomatal conductance and photosynthetically active radiation (PAR). Under water-limited conditions, GPP is mainly limited by the reduction of stomatal conductance.

The LE is dominated by shortwave radiation, as shown in Fig. R1. The distribution of LE and H are impacted by energy balance. The impact of plant hydraulics on the dynamics of LE flux is through its impact on stomatal conductance, while that H is via the iteration in closing the energy balance.

In addition, the water in the leaf can be divided into two distinct parts. one part for transpiration releasing water from leaf to atmosphere, and the other part is used in photosynthetic process (in the light reaction process), in which water molecules (H_2O) are split into molecular oxygen (O_2), protons (H^+) and electrons (e^-) in photosystem II (PSII). The electrons are transferred to photosystem I (PSI) to generate NADPH and to move extra protons across the thylakoid membrane to produce ATP by powering the ATP synthase. NADPH and ATP are subsequently used in the Calvin cycle (in the carbon reaction process) to make sugar. Therefore, the carbon assimilation (as expressed by GPP) is limited by the availability of water within a leaf for light reaction, rather than the water lost through transpiration to the atmosphere. The latter is the important process in regulating the leaf temperature in physiological range. This distinction helps to explain why STEMMUS-SCOPE-PHS results in more improvements in GPP simulation compared with LE and H.

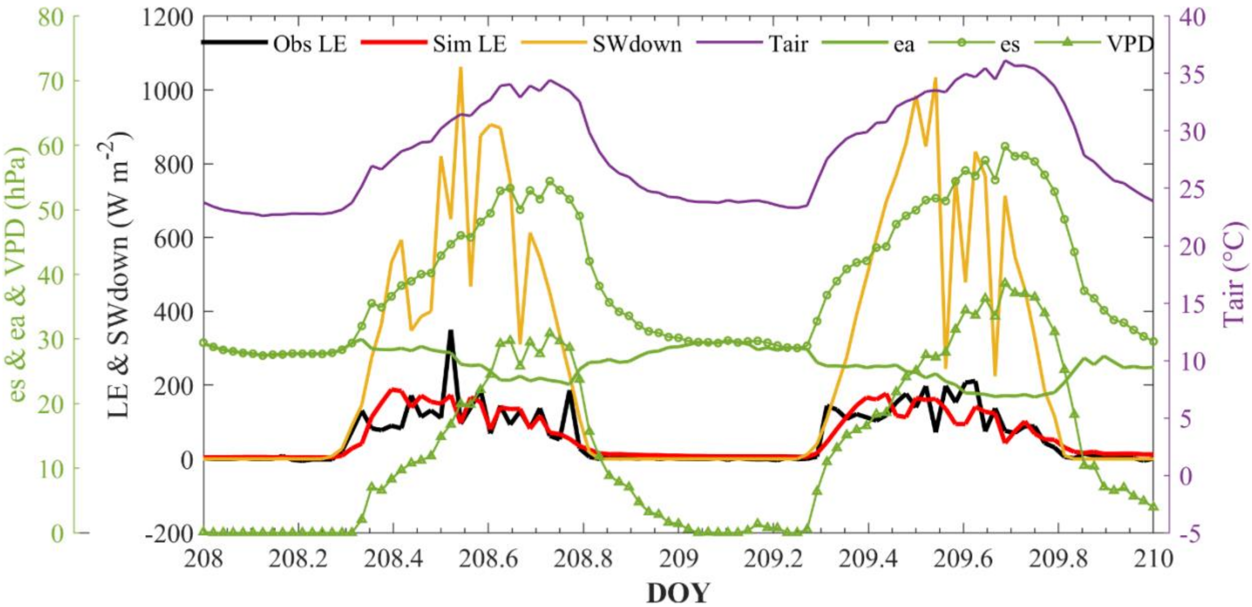

Fig. R1 The dynamics of observed and simulated latent heat flux (Obs LE and Sim LE), observed shortwave downward radiation (SWdown), observed air temperature (Tair). The saturated vapor pressure (es) is calculated based on Tair $es = 6.107 * 10^{\frac{Tair*7.5}{237.3+Tair}}$, and the actual vapor pressure (ea) is calculated by es and observed relative humidity (RH) $ea = es * RH$. The vapor pressure deficit $VPD = es - ea$.

Around Fig 5 and 6 it is not actually clear why Fig. 5 is called well-watered and Fig. 6 is water-stressed if we look at the values of the PHS water stress factor. These are fairly similar? Why is that? And the soil moisture based one never goes below 0.8 or so, so are these actually water stressed conditions?

Thank you for your comments. We selected the two period according to the value of soil-moisture-based-water-stress-factor (SMWSF). In STEMMUS-SCOPE and STEMMUS-SCOPE-PHS, the water stress was used to limit Vcmax to reduce carbon assimilation:

$$V_c = V_{c,max} \times \text{waterstressfactor}, \qquad (R1)$$

During DOY 110-117, the value of SMWSF approximately equals 1, which indicates there is no water stress. During DOY208-215, the value of SMWSF reduce from 0.8 to 0.6, which reduces the $V_{c,max}$ from 20% to 40%, and indicates a water-limited condition.

Why are you not showing the simulations of soil moisture contents and soil temperatures? And even more importantly the land surface temperatures. Please add this and discuss?

Thank you for your suggestion. The comparison of the simulated soil moisture and soil temperature were shown in Supplement Figs. S2-3 and will be moved in the main text, accordingly. Following your suggestion, the comparison of simulated and radiation-retrieved land surface temperature were shown in Fig. R2 and Fig. R3.

The canopy temperature (Tc) showed a consistent dynamic with land surface temperature (LST) retrieved from outgoing longwave radiation at the Hutoucun site. The plants height was about 3-3.5m in 2022. The downward and upward longwave radiation were measured above canopy (at the height of 5 m). Therefore, LST represents a mixed temperature of canopy and soil.

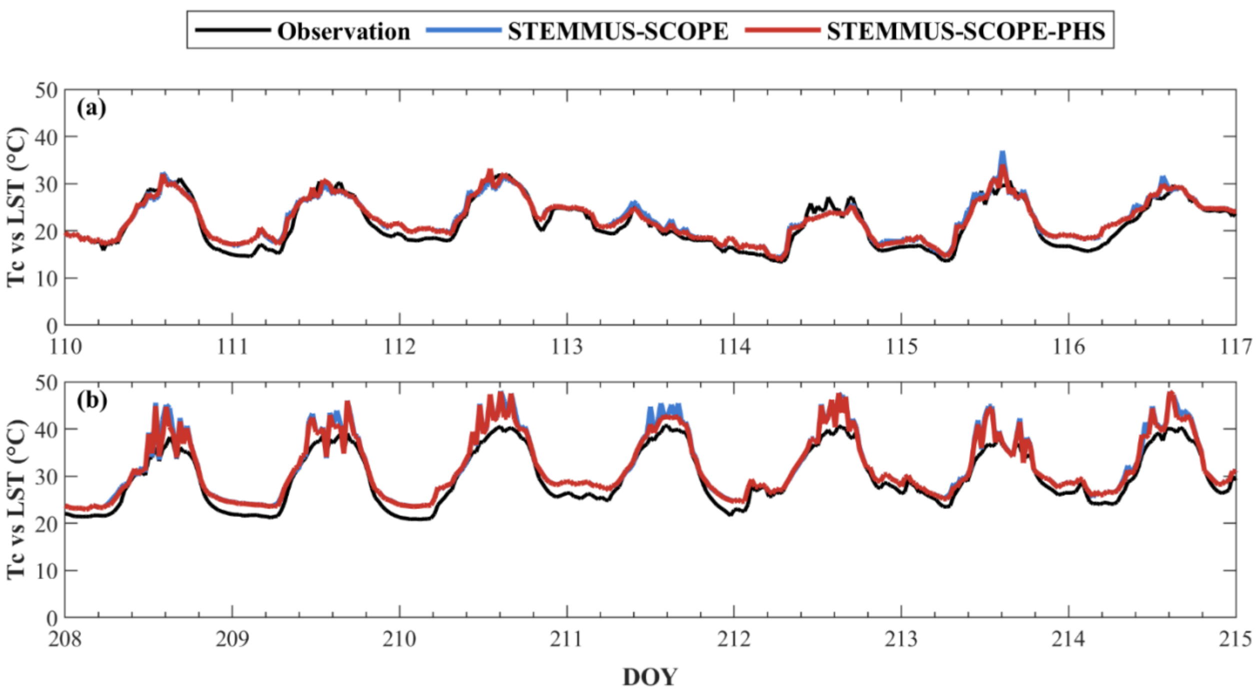

Fig. R2 Comparison of half-hourly dynamics of simulated canopy temperature (Tc) with the retrieved land surface temperature (LST).

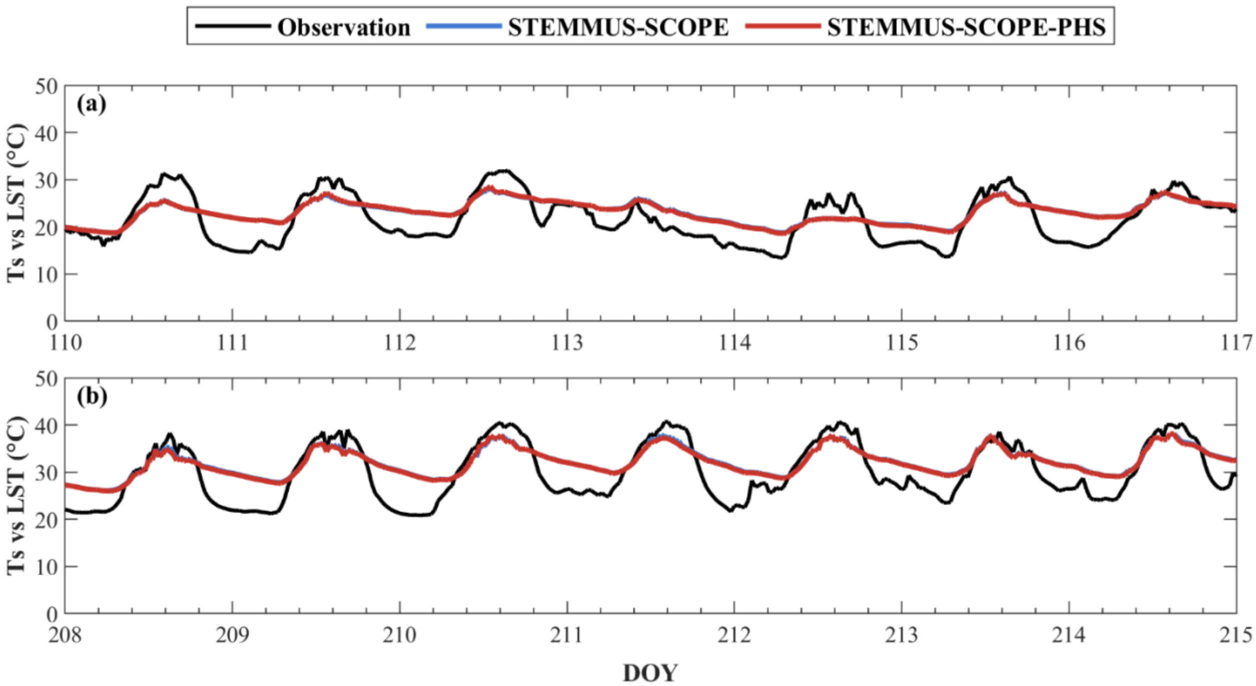

Fig. R3 Comparison of half-hourly dynamics of simulated soil temperature (Ts) with the retrieved land surface temperature (LST).

Section 4.1 represents a somewhat confused narrative. The procedure to correct (not calibrate!) the 5cm soil heat flux should be described in the methods. Then you can discuss here the uncertainties related to this correction. Also, I cannot fully follow the discussion on surface temperature, and this is clearly a crucial state variable that could be incorrect in Stemmus-Scope, yet we are not being shown how it behaves. Moreover, I thought that Stemmus-Scope had a separate soil and canopy temperature?

Thank you for your comments. The equations to correct soil heat flux (Gao et al., 2017) at 5cm to 0cm are added in Section 2 as:

$$G_0 = Gz + \frac{\partial Ts_{ave}}{\partial t} * cv * \Delta z, \quad (R2)$$

$$Ts_{ave} = 0.5 * (LST + T_{5cm}), \quad (R3)$$

Where G_0 (W m^{-2}) is the corrected soil ground heat flux (in this study), Gz (W m^{-2}) is the observed soil heat flux at depth of 5cm. Ts_{ave} (°C) is the average temperature of the retrieved land surface temperature (LST, °C) and 5cm soil temperature (Ts_{5cm}, °C). cv is the volumetric soil heat capacity for the sublayer (Murray and Verhoef, 2007), Δz equals 5 cm. t is the time interval (=1800 s in this study). The LST is calculated based on Stefan-Boltzmann's Law as:

$$LST = \left[\frac{LWup - (1 - \varepsilon_b)LWdown}{\varepsilon_b \delta}\right]^{\frac{1}{4}} - 273.15, \qquad (R4)$$

Where LWup (W m^{-2}) is observed upward longwave radiation, and LWdown (W m^{-2}) is observed downward longwave radiation, ε_b is the broadband emissivity (0.96 in this study) and δ is the Stefan-Boltzmann's constant ($5.67*10^{-8}$ W m^{-2} K^{-4}).

The land surface temperature mentioned in Lines 300-301 "However, the land surface temperature represents a mixed soil-vegetation surface temperature rather than a bare soil temperature", indicates the retrieved land surface temperature (from observed radiation), rather than the model simulated land surface temperature (or 0cm soil temperature). In STEMMUS-SCOPE, the soil temperature and canopy temperature are separately simulated. We have revised the expression as:

In this study, the retrieved land surface temperature (LST) is used as 0 cm soil temperature to calculate soil temperature gradient between 0 – 5 cm due to the lack of measurement on soil surface temperature. Because the radiation is observed at the height of 5m (above canopy), the retrieved LST represents a mixed soil-vegetation surface temperature rather than a bare soil temperature. This assumption may introduce uncertainties in the accuracy of corrected G_0.

Section 4.2: I know that the authors know that SIF is also affected by plant water stress via leaf potential. Why is this not mentioned here, or even better, implemented in the model?

Thank you for your comments. Improving the SIF simulation is beyond the scope of this work. The SIF in STEMMUS-SCOPE is based on an empirical model (Van Der Tol et al., 2014). The plant hydraulics has not been used in SIF calculation so far. Improving SIF simulations by integrating a mechanistic light response open and close (MLROC) (Gu et al., 2019; Gu et al., 2023) is in progress.

References:

van der Tol, C., Berry, J.A., Campbell, P.K. and Rascher, U., 2014. Models of fluorescence and photosynthesis for interpreting measurements of solar-induced chlorophyll fluorescence. J Geophys Res Biogeosci, 119(12): 2312-2327.

Gu, L., Han, J., Wood, J. D., Chang, C. Y.-Y., and Sun, Y.: Sun-induced Chl fluorescence and its importance for biophysical modeling of photosynthesis based on light reactions, New Phytologist, 223, 1179-1191, https://doi.org/10.1111/nph.15796, 2019.

Gu, L., Grodzinski, B., Han, J., Marie, T., Zhang, Y.-J., Song, Y. C., and Sun, Y.: An exploratory steady-state redox model of photosynthetic linear electron transport for use in complete modelling of photosynthesis for broad applications, Plant, Cell & Environment, 46, 1540-1561, https://doi.org/10.1111/pce.14563, 2023.

In the Introduction quite a bit is made of this vegetation growing on a shallow soil, and about its foggy atmospheric conditions, yet you do not come back to this in the discussion. How does this affect things like the total soil moisture reservoir, capillary rise etc.

Thank you for your comments. As shown in Fig. R1, the observed peaks of latent heat flux (obs LE) and vapor pressure deficit (VPD) do not coincide, with the peak of VPD lagging behind the peak of LE. LE is the part of energy used for transpiration. Therefore, it indicates that transpiration is controlled by soil moisture/plant water status, rather than the air water status at this site.

The plant hydraulics process considers the root water uptake, enhancing the interaction of root water potential and soil water potential, and improving the accuracy of soil moisture simulation (Fig. R4).

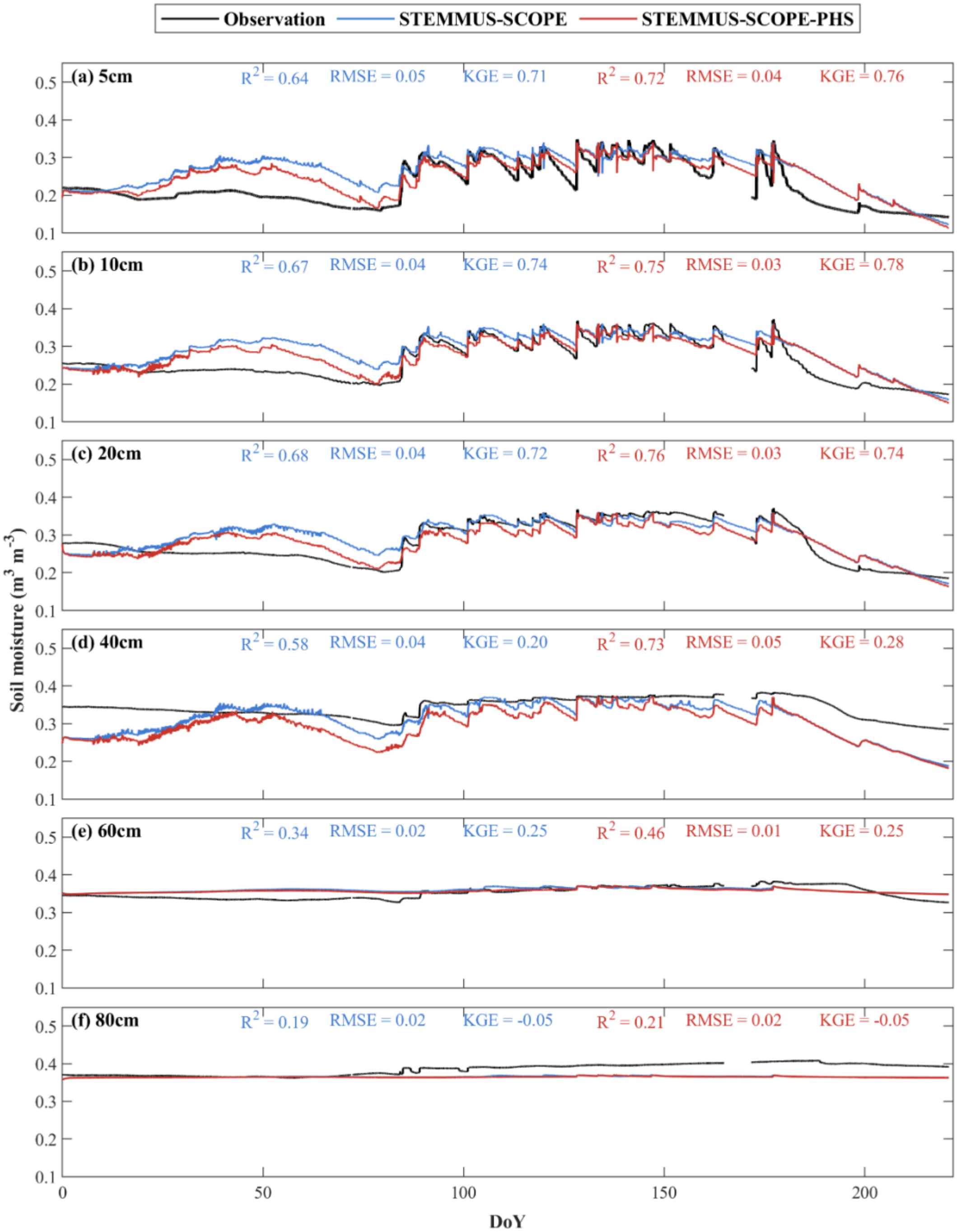

Fig. R4 Comparison of half-hourly simulated and observed soil moisture at the depth of 5, 10, 20, 40, 60 and 80 cm. The blue and red line are results of STEMMUS-SCOPE and STEMMUS-SOCPE-PHS, respectively.

The English needs considerable improvement. I had a go at some things (see below), but a thorough check of your text is required.

Thank you for your comment. We will check and correct English grammar in the whole paper.

Minor comments and technical comments

Line 34: Replace ‘stomata opening’ by ‘extent of stomatal opening’?

Thank you for your comments. It has been revised as:

Water stress is utilized to quantify the effects of droughts, from both soil and atmosphere, on plant physiological and biochemical processes (Torres-Ruiz et al., 2024), such as the extent of stomatal opening and photosynthesis.

Line 36: Say: ‘as a result of limited data availability’

Thank you for your comments. It has been revised as:

Water stress can be characterized well by in-situ observations of soil moisture, plant water content, and leaf water potential, yet, such observations are limited to point scale as a result of limited data availability.

Line 40: Say: ‘the simulation and prediction of water stress’

Thank you for your comments. The sentence has been revised as:

Physics-based Earth System Models (ESMs) (Lawrence et al., 2019; Li et al., 2021; TYREE and EWERS, 1991) enable the simulation and prediction of water stress at various spatiotemporal scales, ranging from minutes to decades, and from sites to ecosystem scale, overcoming the limitation of in-situ and remote sensing observations.

Line 43: Does STEMMUS-SCOPE not also do the soil water balance? And say ‘the energy balance’

Thank you for your comments, and apologize for the unclear description. The STEMMUS-SCOPE do both the soil and vegetation water balance. That sentence has been revised as:

STEMMUS-SCOPE is a Soil-Plant-Atmosphere Continuum (SPAC) model integrating photosynthesis, fluorescence emission, and transfer of energy, mass, and momentum (Wang et al., 2021).

Line 46: Are you saying that for 2 out of the 172 sites it was overestimating the BR??

Thank you for your comment. According to the figure 1 in Abramowitz et al. (2024), they show the STEMMUS-SCOPE model underestimated Bowen Ratio for 170 PLUMBER2 sites. In Tang et al. (2024) and Wang et al. (2021), the authors did not compare the results of simulated and observed Bowen Ratio. We did not include the results from Ningxia and Yanglin in the sentence at Line 46. In this study, the overestimated Bowen ratio during daytime was improved by considering plant hydraulics (Fig. R5).

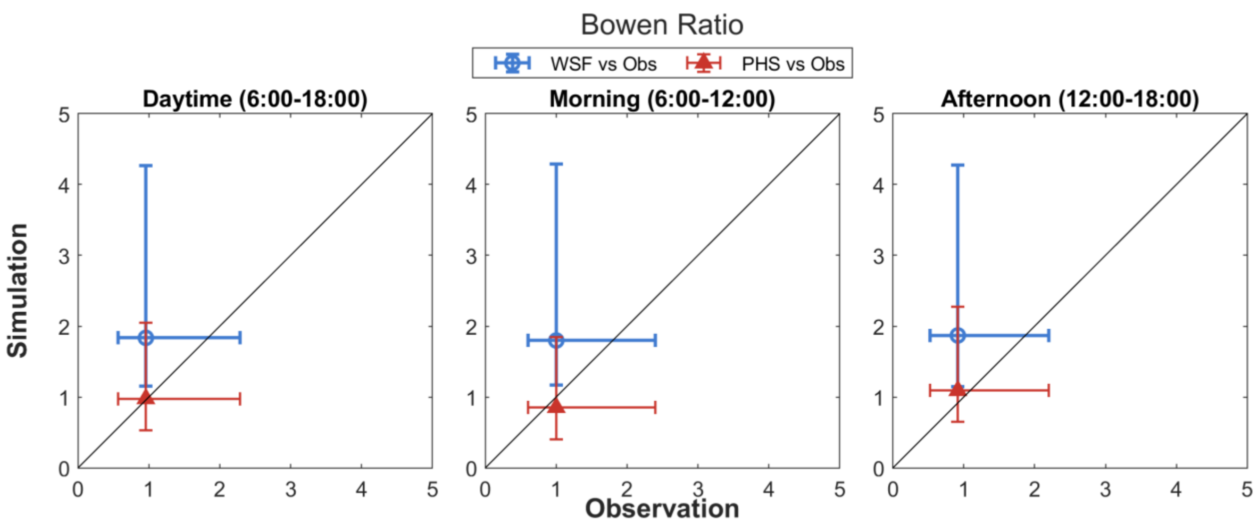

Fig. R5 Comparison of simulated Bowen ratio. The blue plot is the mean value of STEMMUS-SCOPE vs observation, and the red triangle is the mean value of STEMMUS-SCOPE-PHS vs observation. Daytime includes data from 6:00 to 18:00. Morning includes data from 6:00-12:00. Afternoon includes data from 12:00 to 18:00.

Line 46/47. It is not clear exactly what is mean by 'indicating more energy was allocated to latent heat flux for transpiration'? Do you mean 'according to the model calculations, compared to the measurements'?

Thank you for your comments. Yes, compared with the observation, the STEMMUS-SCOPE model underestimated Bowen Ratio (Abramowitz et al., 2024). We have revised this sentence as follows:

> *The results showed that the STEMMUS-SCOPE systematically underestimated the Bowen ratio ($\frac{H}{LE}$, where H is sensible heat flux, and LE is latent heat flux) across 170 flux tower sites*

compared with observation, indicating the STEMMUS-SCOPE model trends to allocate more energy to latent heat flux for transpiration (Abramowitz et al., 2024).

Line 48: ...'for the same NEE'. The same as what? I think there is way to explain better what you are trying to say here. For example by breaking up the sentence.

Thank for your comments. We have revised the sentence as follows:

The results showed that the STEMMUS-SCOPE systematically underestimated the Bowen ratio ($\frac{H}{LE}$, where H is sensible heat flux, and LE is latent heat flux) across 170 flux tower sites compared with observation, indicating the STEMMUS-SCOPE model trends to allocate more energy to latent heat flux for transpiration (Abramowitz et al., 2024). The water use efficiency is calculated by $\frac{NEE}{LE}$, where NEE is net ecosystem exchange. Given that the simulated NEE is similar to the observed NEE, the STEMMUS-SCOPE tends to underestimate water use efficiency. The lower water use efficiency potentially suggests an underestimation on water stress.

Line 53: Perhaps say: 'atmospheric' instead?

Thank you for your suggestions. The sentence has been revised as:

However, it does not consider the water stress induced by either interior plant hydraulics or from the atmospheric evaporative demand (Li et al., 2021; Xie et al., 2023; Xu et al., 2016).

Line 58: 'The distance over which...'

Thank you for your suggestions. The sentence has been revised as:

In fact, the water transport within the plant vessel system can be described by Darcy's Law ($q = K \times \frac{\Delta h}{L}$, where q is water flux, K is hydraulic conductivity, Δh is the water potential gradient, and L is the distance over which water potential drops).

Line 73: What is meant by the 'big-tree conception'?

Thank you for your question. The “big-tree” conception was proposed by Li et al. (2021), which considered plant hydraulics and plant water storage in Noah-MP-PHS model. It is a conception in contrast to “big-leaf” model.

Line 74: water storage in the soil, plant or both?

Thank you for your comment. In Noah-MP-PHS, the water storage in plant (stem and canopy) was considered. This sentence has been revised as:

> *Li et al. (2021) proposed the big-tree conception by considering whole plant hydraulics with water storage in stem and canopy in the Noah-MP model (i.e. Noah-MP-PHS), and the results showed that Noah-MP-PHS captured different hydraulics behaviours of isohydric (red-maple) and an-isohydric (red-oak) trees during a dry-down period in Michigan, USA.*

Line 75: Is the word ‘trees’ missing after ‘an-isohydric (red-oak)’?

Thank you for your comments. See above sentence.

Line 79-80: I have trouble following this sentence.

Thank you for your comment, and apologize to the confused expression. We have removed this sentence.

Line 82: Replace ‘knowledge’ by ‘understanding’?

Thank you for your suggestion. This sentence has been revised as:

> *Can we improve our understanding of the response of plants to drought over the karst region by considering plant hydraulics in the STEMMUS-SCOPE model?*

Line 97: What does it mean that ‘..the weather is moderate and rainy’. Please use a more detailed scientific description!

Thank you for your comment. We have revised the sentence as:

> *This area is characterized by a subtropical monsoon climate, with relatively mild winters and hot summers. Precipitation is abundant, primarily concentrated during the summer months*

due to monsoonal rainfall. The annual average temperature ranges from 15 to 17 °C, with mean air temperatures of approximately 2 °C in the coldest month (January) and 40 °C in the warmest month (August).

Line 99: This high relative humidity and fogginess makes for a reduced atmospheric demand, which combined with the plant water stress make for a unique feature for this site. Should more be made of this?

We appreciate for your comment. We will revise the introduction accordingly to highlight the unique feature for this site.

Line 100: What is the texture of this 'thin soil layer'?

Thank you for your question. The soil texture at 0-5 cm, 5-10 cm, 10-100 cm are sandy loam, loam, and silt loam. It has been added in the draft.

Line 104: Can you also give the English name of the vegetation?

Thank you for your suggestions. The English name of the vegetation is sweet olive, and it has been added in the sentence:

The data is collected from a flux tower (10 m) over an Osmanthus fragrans (sweet olive) plantation, with an average tree height of 3-3.5 m.

Line 110: The data weren't just averaged by this software but also corrected? List the type of corrections? Or refer to paper?

Thanks for your comments. We have revised the sentences as:

The post-processing for splitting net ecosystem exchange (NEE) into the gross primary production (GPP) and the ecosystem respiration (Re) was conducted by a R package: REddyproc (https://www.bgc-jena.mpg.de/5624551/REddyProc-Rpackage, Max Planck Institute, last accessed on 28th July, 2024) (Wutzler et al., 2018). The post-processing includes u threshold distribution by the moving point mothed (Reichstein et al., 2005a), NEE gap filling by marginal distribution sampling (MDS) method (Reichstein et al., 2005b), and nighttime-based flux partitioning (Reichstein et al., 2005a).*

Line 113: Dd you mean to say that the SIF system was installed? Not 'conducted'?

Thank you for your comments. The sentence has been revised as:

> *An automatic solar-induced chlorophyll fluorescence (SIF) system was installed since 2021, detailed information can be found in Wang et al. (2023).*

Line 115: The bit about the soil texture needs to go into the previous section

Thank you for your suggestion. The introduction of soil texture had been moved to the previous section accordingly.

Line 115-117: Give the Manufacturers and versions of the probes? And their operating principle (e.g. Capacitance probes). Also, if this is a plantation, were there rows of trees? Were the sensors within or between rows?

Thank you for your comment. We have added the information of the probes.

> *Soil moisture (CS616, Campbell Scientific Inc., using a time-domain reflectometry principle) and soil temperature (AV-10T, Rainroot Scientific Limited) probes were installed at the depth of 5, 10, 20, 40, 60, and 80 cm. They were installed at a single location about 1.5 m south of the flux tower within the rows of trees. Three soil heat flux plates (HFP01SC, Hukseflux) were placed horizontally in parallel at the depth of 5 cm. A set of PSY-1 Plant Stem Psychrometer (ICT International, thermocouple sensor) was installed in a branch to collect in-situ xylem water potential from 27th July to 20th September, 2022.*

Line 117: At what height in the canopy were the Plant Stem Psychrometers installed. And why was it installed so close to the edge of the field (see Figure 1)? Would that not have affected its readings?

Thank you for your comments. The Plant Stem Psychrometers (PSY-1) were installed at the height of 1.9 m. The sensors were installed at the downwind of main wind direction to ensure the consistency with fluxes observation.

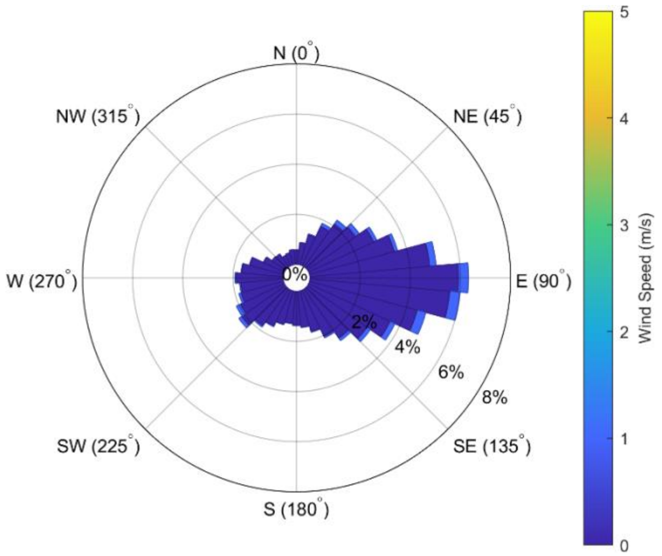

Fig. R6 Wind direction and wind speed at the Hutoucun site

Line 118: Say ‘obtained’ not ‘collected’

Thank you for your suggestions. The sentence has been revised as:

> *The leaf area index (LAI) was obtained from MODIS MCD15A2H.006, an 8-day composite LAI dataset with a spatial resolution of 500 m via Google Earth Engine. Quality control flags were used to remove pixels affected by clouds.*

Line 128: Best to remove the word ‘elaborate’ because this tells us nothing about model quality.

Thank you for your suggestions. The word “elaborate” has been removed.

> *The STEMMUS-SCOPE model is a process-based model which integrates simultaneous energy, mass and momentum transport in soil and plant, and radiation transfer and biochemical process in the canopy (Tang et al., 2024; Van Der Tol et al., 2009; Wang et al., 2021; Zeng et al., 2011a, b).*

Line 129: Is there ‘momentum transport’ in soil?

Thank you for your comment. In STEMMUS, the dry air movement in the soil has been considered, which results in the air pressure change in the soil. The air pressure changes at different depths are termed momentum transport.

Line 133: Remove ‘is considered’

Thank you for your comments. The sentence has been revised as:

In STEMMMUS-SCOPE, water and heat fluxes in SPAC are fully coupled, and the model also accounts for the transport of vapor and dry air in unsaturated soil.

Line 134/135: ‘multiple layers of spectra information’ sounds really vague. Explain more. Also, if you have all this spectral modelling, then say what other satellite products it could be compared to?

Thank you for your comments. The sentence has been revised as:

Additionally, it is capable of simulating of spectra information and SIF of multiple layers (the default value is 30, and the value is changeable if results of more layers are needed), making it possible to compare with in-situ and satellite SIF data. The model calculates the spectrum from 400 nm to 50 um, enable to compare simulation results with satellite data, such as GOSAT (Lee et al., 2013), GOME-2 (Joiner et al., 2013), Sentinel-3 (Prikaziuk et al., 2021; Prikaziuk and Van Der Tol, 2019).

Line 138: What is ‘It’ referring to? And why/how does this ‘peristomatal water flux’ matter? This seems like a random remark.

Thank you for your comment. ‘It’ means the stomatal conductance scheme. The relative humidity change is driven by the changes of peristomatal water flux. We have revised it as follows:

In STEMMUS-SCOPE, the stomatal conductance is calculated based on Ball et al. (1987), in which the stomatal conductance is regulated by relative humidity, carbon dioxide concentration and carbon assimilation amount (See Appendix A1). The stomatal conductance scheme was criticized because it suggests that stomata sense transpiration rather than relative humidity (Medlyn et al., 2011).

Line 141: Where does the equation for SMWSF come from?

Thank you for your question. The equation of SMWSF was used in Wang et al. (2021). The citation has been added.

Line 148: ‘plant hydraulics (PHS) process’. Do you mean system?

Thank you for your question. The “S” means stress. We have revised this sentence as:

> *To overcome the above drawbacks, this study aims to couple the plant hydraulics stress (PHS) process into the STEMMUS-SCOPE model (hereafter STEMMUS-SCOPE-PHS) to explore the plant response to water stress via plant hydraulics and to enhance its representation of biophysical and mechanistic process in a forest ecosystem.*

Line 154: say ‘atmospheric vapour pressure deficit’

Thank you for your suggestion. The sentence has been revised as:

> *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 atmospheric vapour pressure deficit on stomatal regulation.*

Line 161: Add ‘which equals transpiration, Trans.’ After ‘by roots to water released through stomata (Fig. 2).’ Then remove its explanation a few lines later.

Thank you for your suggestions. The sentence has been revised as:

> *The plant hydraulics pathway describes the process from water absorbed by roots to water released through stomata (Fig. 2) which equals transpiration ($Trans$).*

Line 167: write ‘plant tissues and soil are assumed to be porous media’

Thank you for your suggestion. The sentence has been revised as:

> *The plant tissues and soil are assumed to be porous media.*

Line 169: Darcy's law uses conductivities, not conductances. Is this an issue?

Thank you for your comments. The transfer between conductivity to conductance had been mentioned in Appendix A3.1.5, A3.1.7 and A3.1.8.

Line 179: Eq. 6 is not an energy balance model, and how is Psi_air shown in Fig. 2 used to calculate transpiration?

Thank you for your comment. Transpiration is calculated by actual canopy latent heat flux (LE_c). The air water potential (ψ_{air}) is not used in calculation of transpiration. It has been revised as

The transpiration (Trans) can be calculated by

$$Trans = \frac{LE_c}{m2mm \cdot \lambda}, \qquad (R5, eq. 6\ in\ main\ text)$$

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}.

Figure 2: Define Psi_air and explain how it is calculated/used. I cannot see it mentioned in the methodology?

Thank you for your comment. The air water potential (ψ_{air}) is calculated by

$$\psi_{air} = \frac{R * T_{air}}{V_w} ln(RH), \qquad (R6)$$

where R is gas constants (=8.314 J mol^{-1} K^{-1}), T_{air} is air temperature (K), V_w is partial molar volume of liquid water (=18 cm^3 mol^{-1}). RH is relative humidity.

The ψ_{air} was calculated based on in-situ observed air temperature (T_{air}), and relative humidity (RH) to validate the range of simulated root, stem and leaf water potentials (Figure 7). The ψ_{air} is not included in plant hydraulic pathway.

Line 186-187: I would say: 'multiplying the maximum carboxylation rate under a well-watered condition by the water stress factor'. Also you need to make it clear that this is now a different factor from the one presented earlier that was based on SMC. Properly introduce phwsf in the text

Thank for your comments. We have revised it as follows:

> *The water stress effect on photosynthesis is represented by multiplying the maximum carboxylation rate ($Vcmax$, $\mu mol\ m^{-2}s^{-1}$) under a well-watered condition by a leaf-water-potential-based plant water stress factor (phwsf).*

Line 190-197. You need to make it clear here that these equations were taken from the ED2 and CLM model, otherwise the subscripts don't make sense.

Thank you for your comments. We have revised it as:

> *Two parameterizations ($phwsf_{ED2}$ from ED2, and $phwsf_{CLM}$ from CLM5) of water stress factor were coupled into the STEMMUS-SCOPE-PHS to account for different types of plants. The plant water stress factor $phwsf_{ED2}$ (Xu et al., 2016) is set as the default option in the STEMMUS-SCOPE-PHS.*
>
> *It can be calculated as*
>
> $$phwsf_{ED2} = \left[1 + \left(\frac{\psi_{leaf}}{P50_{leaf}}\right)^{a}\right]^{-1}, \qquad (R7, eq. 8\ in\ main\ text)$$
>
> *where $P50_{leaf}$ (m) is the water potential at the 50% hydraulic conductance loss and a is a shape parameter.*
>
> *The other optional parameterization of plant water stress factor $phwsf_{CLM}$ (Kennedy et al., 2019) is calculated as*
>
> $$phwsf_{CLM} = 2^{-\left(\frac{\psi_{leaf}}{P50_{leaf}}\right)^{ck_{leaf}}}, \qquad (R8, eq. 9\ in\ main\ text)$$
>
> *where ck_{leaf} is a shape factor.*

Line 219 : why are you referring to these indices as 'statistic proxies'?

Thank you for your comments. The sentence has been revised as:

> *For the sensible heat flux (H), statistics (R^2 and RMSE) show that the result of STEMMUS-SCOPE-PHS is approximately equal to that of STEMMUS-SCOPE, although the values of KGE show that the performance of STEMMUS-SCOPE-PHS (0.70) is better than that of the STEMMUS-SCOPE (0.52).*

Line 247: What is meant with ‘clearly diurnal dynamics’? Do you mean ‘clearly improved diurnal dynamics’?

Thank you for your question. What we want to express is that PHWSF has diurnal dynamics, while SMWSF does not. In the original manuscript, Fig. S4 and Fig.S5 presented the daily results. We have replaced the two figures with a half-hourly comparison to provide a more detailed analysis of the temporal dynamics.

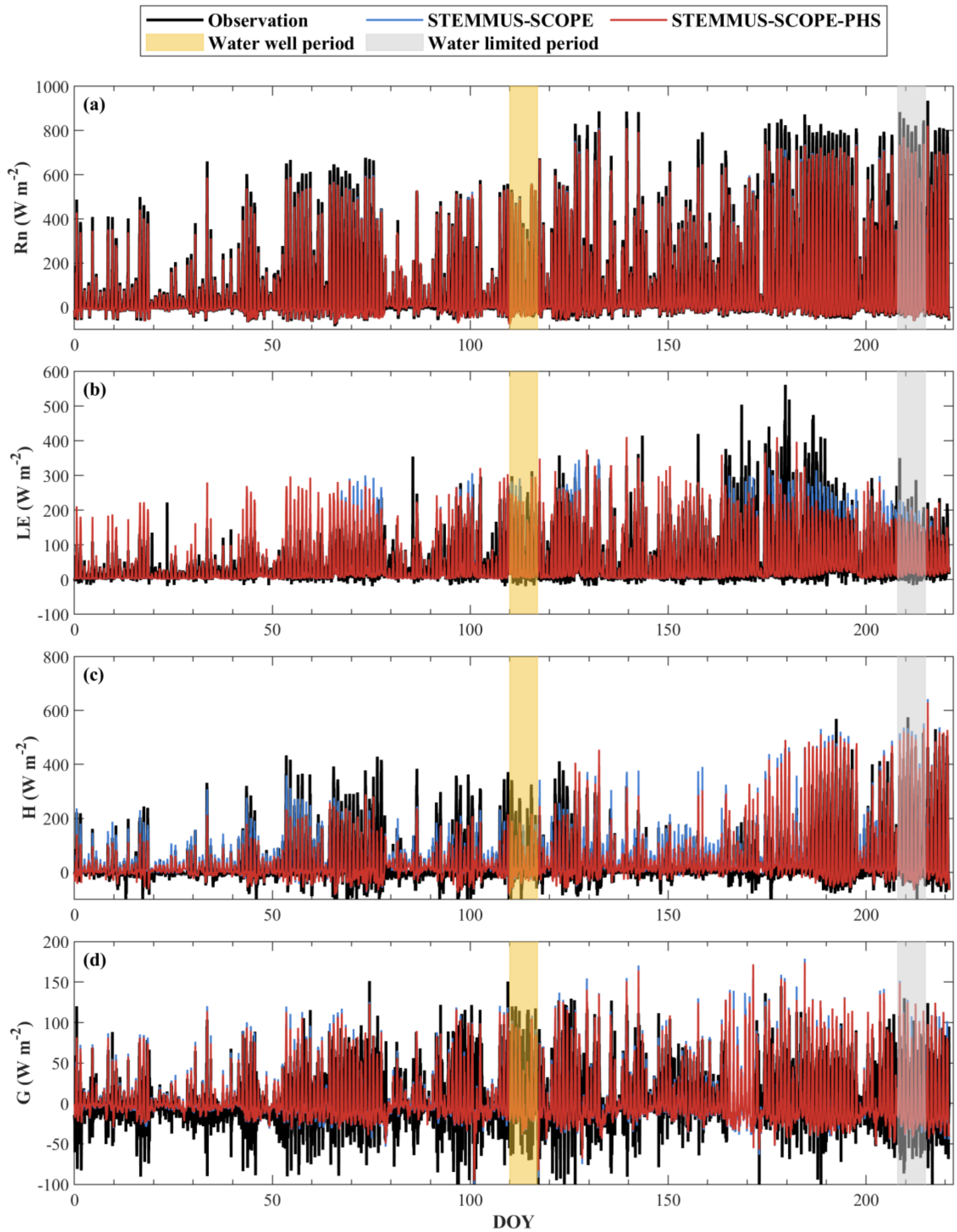

Fig. S4 Comparing of half-hourly simulated and observed net radiation (a), latent heat flux (b), sensible heat flux (c) and soil heat flux (d) from 1st January to 9th August, 2022 at Hutoucun site. The blue and red line are the simulation from STEMMUS-SCOPE and STEMMUS-SCOPE-PHS, respectively. The water-well period and water-limited period are marked in yellow and grey, respectively.

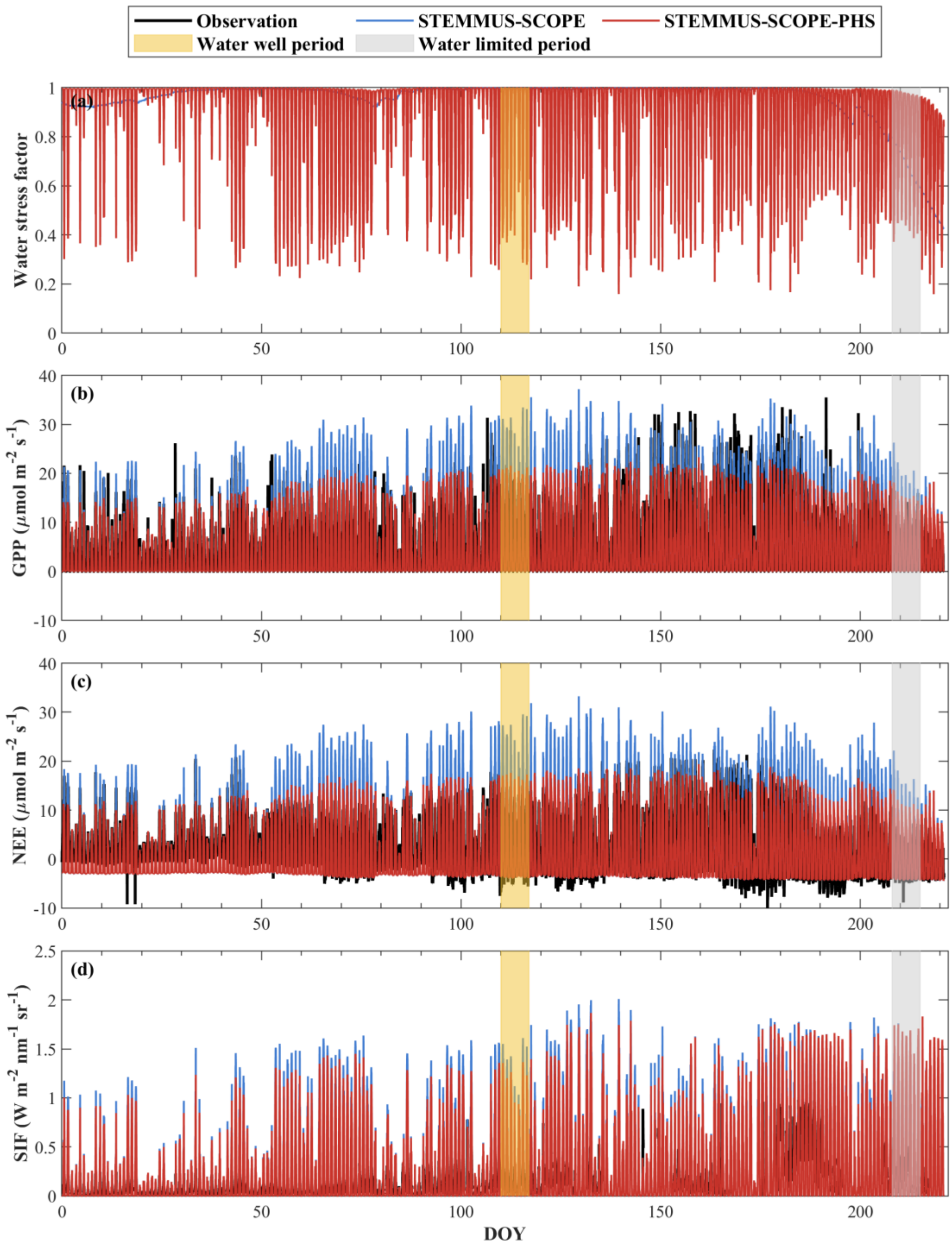

Fig. S5 Comparing of half-hourly (a) simulated water stress factor, (b) simulated and observed GPP, (c) simulated and observed NEE, (d) simulated and observed SIF from 1st January to 9th August, 2022 at Hutoucun site. The blue and red line are the simulation from STEMMUS-SCOPE and STEMMUS-SCOPE-PHS, respectively. The water stress factors are not observed, so only the results from two models were shown. The water-well period and water-limited period are marked in yellow and grey, respectively.

Line 249: This should be 'well-watered condition'.

Thank you for your comment. The sentence has been revised as:

> *As shown in Fig. 5, the SMWSF is approximately equal to 1 from DOY 110-117, which indicates a well-watered condition.*

Line 254: Also how does higher water consumption result in greater water stress? That also depends on the root-zone soil water store and hydraulic conductivity?

Thank you for your comments. In STEMMUS-SCOPE-PHS, the greater the water stress, the lower the value of water stress factor (SMWSF and PHWSF). Yes, the changes in plant water stress (represented by plant water stress factor) are related to root-zone soil water storage and hydraulic conductivity. Plant water stress factor is calculated from leaf water potential, and the leaf water potential was indirectly affected by root-zone soil water potential, and hydraulic conductivity. An explanation has been added to the sentence.

> *This is because the transpiration increases in the afternoon, leading to higher water consumption, reducing leaf water potential, further resulting in greater water stress (lower value of PHWSF).*

Line 254/255: The water stress is also relieved by replenishment of the root zone, including by capillary rise possibly. This should be mentioned.

Thank you for your suggestion. We will add the water re-distribution accordingly.

Line 275: say 'until they reach equilibrium'

Thank you for your comment. The sentence has been revised as:

> *In the nighttime, the value of plant water potential is close to the value of root zone soil water potential as roots absorb water from the soil until they reach equilibrium.*

Line 307: The equations relating to SIF should have been introduced in the Methods section.

Thank you for your suggestion. Improving the SIF simulation is beyond the scope of this paper. In the STEMMUS-SCOPE-PHS and STEMMUS-SCOPE, the calculation of SIF is according to Van Der Tol et al. (2014).

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Line 335: say '..for water-limited conditions'

Thank you for your suggestion. The sentence has been revised as:

> *The simulated and observed plant water potentials were compared only for the water-limited conditions (Fig. 7) due to the data availability of observed stem water potential.*

Line 340/341: say 'Neglecting the plant water storage'.

Thank you for your suggestion. The sentence has been revised as:

> *Neglecting the plant water storage may overestimate the water supply from roots and results in a less negative plant water potential compared with observation. This result suggests that plant water storage needs to be considered in further development.*

Line 342: There are various models that have already implemented this. Please refer to some of them?

Thank you for your comment. We have revised it as:

> *Li et al. (2021) and Xie et al. (2023) found that a low stem water storage can result in a more negative minimum stem water potential in Noah-MP-PHS and VIP-PHS models, which is consistent with our results as shown in Figure 7. Our results demonstrate the importance of considering plant water storage to accurately simulate plant water potential.*

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