

We have included the reviewer's comments and our response below. The reviewer's comments are copied in black text, and our responses are in *light blue and italics*.

This manuscript describes how climatic drivers affect evapotranspiration, carbon flux, and ecophysiological indices across Southeast Asia (SEA) by numerical experiments. The authors gathered 20 tower flux data, calibrated the mechanistic ecohydrological model, and conducted the numerical experiment by perturbing the climatic drivers. They found that most vegetation in SEA is energy-limited rather than water-limited, and that the impact of perturbed climatic drivers on fluxes or indices varied across drivers and vegetation types. As synthesizing research in the region remains limited, this research focuses on the important topic. However, it has significant problems with methodology and analysis.

1. Why did the authors include China and Taiwan in SEA? Typically, SEA is defined as the group of countries (Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, Singapore, Indonesia, Brunei, Philippines, and East Timor), and most articles follows this definition, such as Pan et al. (2024; Nature), Estoque et al. (2019; Nat. Commun.), and Pletcher et al. (2022; Ecography). According to Table 2, the annual air temperature of the CN-Dan site is 2.2 °C. Including such vegetation sites in cold environments would prevent the disentangling of the nature of the vegetation mechanism in SEA. Removing the sites in China and Taiwan, especially in the Tibetan region, from the analysis is recommended, though this removal would drastically change the results, discussion, and conclusion.

Sorry for the confusion in using a non-conventional definition of South-East Asia (SEA). We understand that the term SEA usually refers to the group of countries mentioned by the reviewer. Our inclusion of Tibetan region and Taiwan sites in SEA, however, is based on two reasons encompassing a broader ecohydrological perspective: 1) The Tibetan region is included because it is the headwater of the Mekong River and Salween River, and thus ecosystems in this region affect downstream water yield. However, we are more than happy to remove them from the analysis if the Editor and reviewer deem this more appropriate, even though we believe including them improves the quality of the results. 2) As the number of flux tower sites available in the conventional defined region of SEA is limited, some important ecosystems lack representations in the flux dataset. For instance, there is a lack of corresponding flux tower observations for ecosystems such as Montane cloud forests (located in the southern part of Peninsular Malaysia) and evergreen needleleaf forests (such as some high-elevation areas of northern Vietnam). Consequently, we are "borrowing" some flux tower sites from ecosystems and climates which are close to this region to use them as a surrogate for typical ecosystems in SEA. This includes using TW-Chn to represent the Montane cloud forest and CN-Qia to represent the evergreen needleleaf biomes. Again, we are happy to remove them from our analysis if

the editor and reviewers feel it brings confusion. We will add a statement in the revision to clarify the two points

2. To conduct such a synthetic analysis, describing the method for post-processing eddy covariance flux data is vital because it affects the output flux values heavily. The authors provide no information on the flux data source or the flux post-processing protocol, including conversion from raw 10-20 Hz data to half-hourly or hourly data, quality control of the hourly data, and the carbon flux partitioning method. Lacking this kind of information will reduce the reproducibility and reliability of this research. (where can we find the information)

Thank you for the suggestion. We hope to clarify that we do not carry any analysis on the raw flux tower data. All the data (for all sites) are collected from existing databases, including AsiaFlux, ChinaFlux, and FLUXNET2015. Differently from FLUXNET2015, the AsiaFlux sites (ID-PDF, ID-BKS, MY-MLM, MY-PSO, TH-RFC, TH-DFR, TH-SKR, TH-Mae, CN-Xsh, TW-Chn, CN-Qia) do not follow a centralized, standardized post-processing protocol; AsiaFlux primarily works as a regional repository for diverse site data without unified gap-filling or partitioning (Ueyama et al., 2025). In light of this, we have provided the specific post-processing protocol for each site in the corresponding references in Table 2 of the manuscript. The FLUXNET2015 sites (TH-SKR, HK-MPM, CN-Din, CN-Dan, CN-Hgu) are centrally quality-controlled, using friction velocity thresholds to filter low-turbulence conditions. The filtered net ecosystem exchange time series are gap-filled using marginal distribution sampling and partitioned into GPP and ecosystem respiration using nighttime and daytime partitioning approaches (Pastorello et al., 2020). For the ChinaFlux sites (CN-YJS, CN-ALS, and CN-PDS), quality control, low-turbulence screening, and flux processing are conducted in a site-specific, expert-driven procedure rather than a centralized workflow pipeline. Carbon flux partitioning uses the nighttime partitioning method, which is similar to FLUXNET2015. The ecosystem respiration is calibrated using nighttime NEE and temperature relationships and extrapolated to daytime. The GPP is calculated as the residual between ecosystem respiration and net ecosystem exchange (Fei et al., 2018; Yu et al., 2006). The more detailed description of the post-processing procedure for each ChinaFlux sites can be found in the corresponding publications, including CN-YJS (Fei et al., 2018), CN-ALS (Song et al., 2017), and CN-PDS (Wang et al., 2020). We will clarify these methodological aspects in the revised manuscript.

3. The authors mentioned in the Introduction section that maritime SEA has a slight seasonal variation of precipitation, but mainland SEA has clear wet and dry seasons. This implies that vegetation in the mainland SEA can be water-limited in the dry season. Nevertheless, the authors focused solely on annual values in their numerical experiments and did not discuss the importance of seasonal variations in fluxes and ecophysiological indices. Also, the climatic drivers in the SEA

region exhibit interannual variability induced by the El Niño–Southern Oscillation (ENSO). Some sites experienced ENSO during the studied period. But the authors averaged the fluxes for each DOY across all available years, thereby mixing ENSO effects into the data under neutral conditions. It is recommended to clarify the extent of the interannual variation in each variable before the numerical experiments.

Thank you for the suggestion. We agree that some ecosystems can be water-limited during the dry season, and this can also be reflected in our sensitivity analysis at the annual scale. For example, we found that the GPP of dry deciduous forests at the Thailand site (TH-SKR) has a stronger response to precipitation changes than other subtropical broadleaf forests, indicating that they are more of a water-limited system, see Figure 8H and Table S2 in the manuscript.

We agree that El Niño may somehow affect our analysis. However, we do not have a sufficiently large number of years in most sites to stratify the analysis and separate between ENSO positive and negative years. This would require replacing the local meteorological forcing with some reanalysis datasets, further complicating the interpretation of the results, as reanalysis carries the biases of the atmospheric core and the limited data they assimilate on those regions. Currently, in our study region, the strongest recent El Niño years are 1997-1998 and 2015-2016. Only six sites experienced these El Niño events among the available observations: MY-MLM (2014-2015), TH-RFC (2015-2018), TH-DFR (2015-2017), CN-PDS (2015-2019), and CN-Hgu (2015-2017), CN-YJS (2013-2015). After checking the interannual variation, we found that the El Niño year (warmer and drier) mainly affects the TH-DFR and TH-FRC sites and has less effects on other sites, especially for those in China (Figure R1, Figure R2). Considering the TH-RFC has seven years of data, El Niño effect will be averaged out and only the TH-DFR (tropical dry deciduous) site is largely affected by a single El Niño occurrence since it has only three years of data, and two years of which are affected. However, as there are two more tropical dry deciduous sites (TH-SKR and TH-Mae), we suspect that the overall impact of El Niño on our sensitivity analysis is limited.

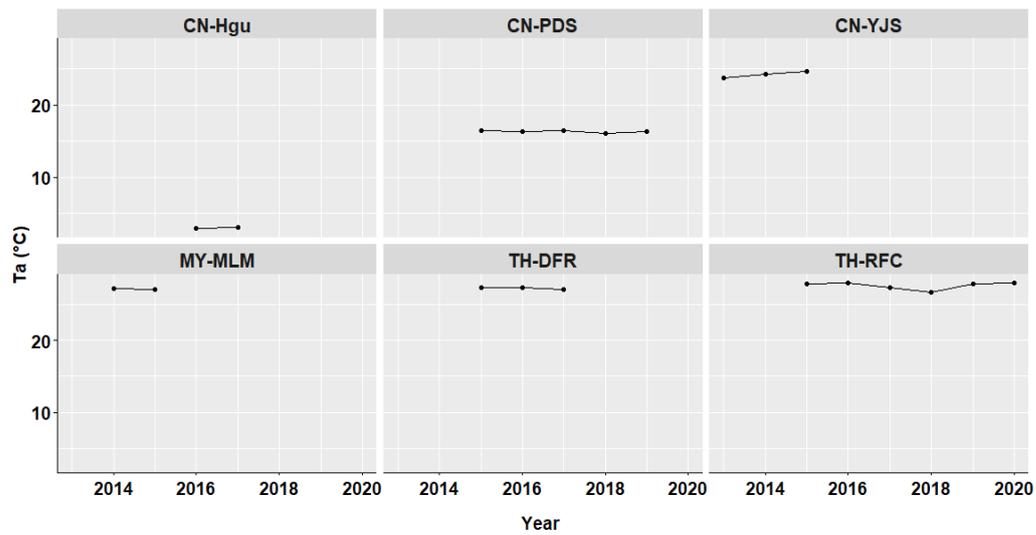


Figure R1. Annual mean temperature for sites where observations overlap with the 2015-2016 El Niño event.

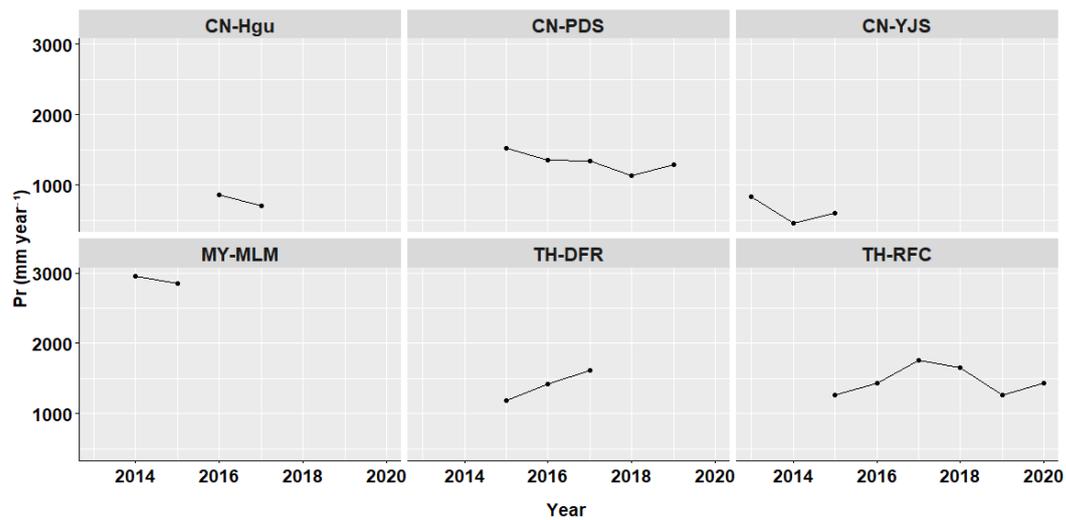


Figure R2. Annual precipitation for sites where observations overlap with the 2015-2016 El Niño event.

Specific comments:

R2.1 L148: I cannot determine the significance of creating the map, as the authors did not analyze it in the Results section. If the authors use this map only to confirm that the flux sites cover representative vegetation in the SEA, I recommend moving the 2.1 section to the supplementary materials.

Thanks for the suggestion. Because this is a synthesis study, we prefer to keep this map in the main text for another reason besides confirming that flux sites cover representative vegetations. This map can help future researchers in attributing the correct land use across Southeast Asia and identifying underrepresented ecosystems in the region. For example, new open-source flux tower sites to cover maize and oil palm plantations of this region will be important because they cover 3.5% and 3% of the area, but were not included in the analysis as the flux tower data are not publicly available so far. Please note that the landcover map is not simply taken from one single source, but it is a detailed combination of different land cover products and, by itself, can be an important reference to other studies in Southeast Asia. Moreover, we are conducting a subsequent study that performs a distributed ecohydrological modelling on the entire domain.

R2.2 L169–171: Some of the annual values mentioned here do not match the numbers in Table 2.

Sorry for the confusion. We have revised this sentence to ensure the values reported are consistent with those in Table 2. “The mean annual precipitation across these sites varies from 520 to 4763 mm year⁻¹, whereas the mean annual air temperature ranges from 2.2 °C to 27.6 °C.”

R2.3 L176: As oil palm is one of the most popular plantations in SEA, not including an oil palm plantation site in the dataset is problematic. The AsiaFlux Database includes at least one dataset at an oil palm plantation site (JOP: Jambi Oil Palm Plantation) from 2014 to 2020. How about adding this site to the analysis?

We agree that oil palm plantations are an important vegetation type in Southeast Asia; it would have been more comprehensive to include the JOP site. The AsiaFlux website did list JOP; however, there is no complete hourly data available yet. For AsiaFlux sites, even though some of them are listed on the website, the data are held by the site PI. That also further illustrates that studying SEA is challenging due to the lack of long-term publicly available data. We also checked the related paper for this JOP site; most of them are from the University of Goettingen group (i.e., Donfack et al., 2021; Meijide et al., 2017; Stiegler et al., 2019). We have collaborated with them before and T&C model has been applied to oil palm ecosystems in the past (e.g. Manoli et al., 2018), but we did not have the permission to use those data when we started this research, and that is why we did not include this site from the beginning. However, they recently made the data available on another website (<https://meta.icos-cp.eu/objects/UPYg0X-IXRklzATpJgE8-CkX>). We will include the JOP site in our final revision.

R2.4 L189–190: The authors' inclusion of the southern part of the Tibetan region is

unreasonable. What relates the source area of the Mekong and Salween rivers to this research?

Please kindly refer to our reply to the main comment no. 1.

R2.5 L195–198: Usually, the energy balance closure (EC) is calculated as $(H + LE) / (R_n - G)$, where G is ground heat flux. If the G is available, the authors should use this definition. By the way, the typical EC value is around 80% (Mauder et al., 2024; Agricultural and Forest Meteorology). It is strange that some of the EC values in Table 2 exceed 100%. The authors need to check whether the energy balance correction is already applied to the energy fluxes at these sites.

Thanks for the suggestion. We checked the four sites where the EC is larger than 100%. Unfortunately, there is no ground heat observation available; however, over the annual scale, G can be safely assumed to be zero. However, as our energy closure is calculated using the mean annual fluxes, this may be affected by missing data. Therefore, we also checked the energy closure $(LE + HS)/R_n$ at the daily scale, assuming at daily scale the closure should be smaller than 100%. Only one site CN-Hgu has median daily energy closure value smaller than 100% (Figure R3, Figure R4). These values at about 100% are probably testifying that for these sites the reported energy budget components have already been corrected for energy closure, as suggested by the reviewer – even though this is not indicated in the metadata (e.g., Hsieh et al., 2008; Wang et al., 2022). Overall, energy budget closure is simply reported to demonstrate that data for many flux-tower observations in the SEA region have large uncertainties.

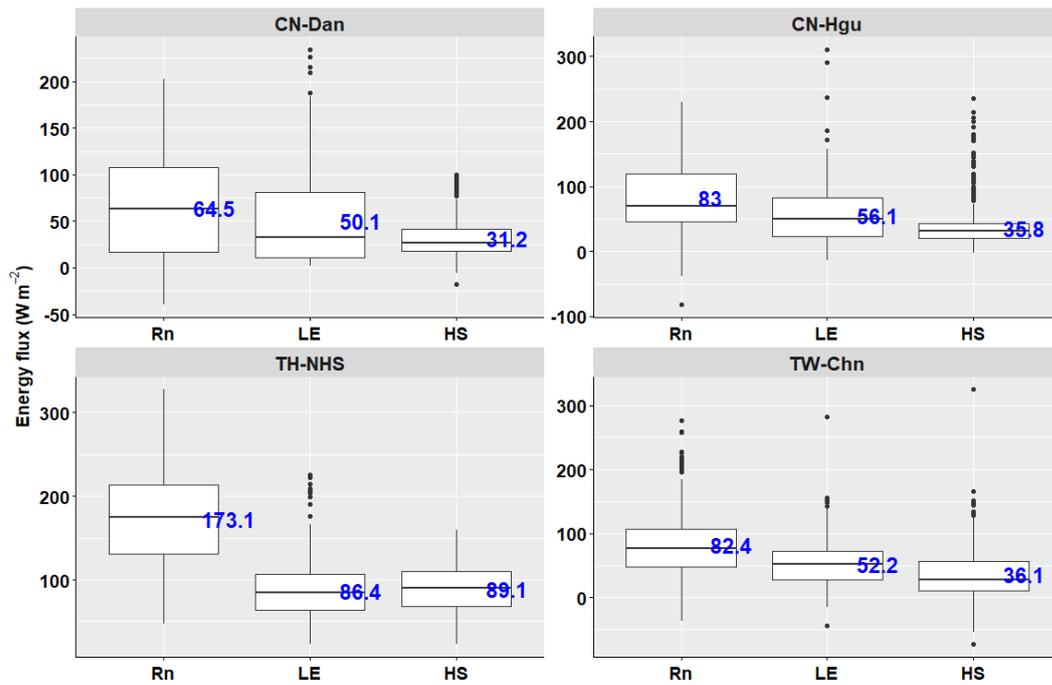


Figure R3. The distribution of energy fluxes at daily scale for four sites, R_n is net radiation, LE is latent heat, and HS is sensible heat. The boxplots represent the median, 25%, and 75% percentiles. The labelled number is the mean of the daily fluxes.

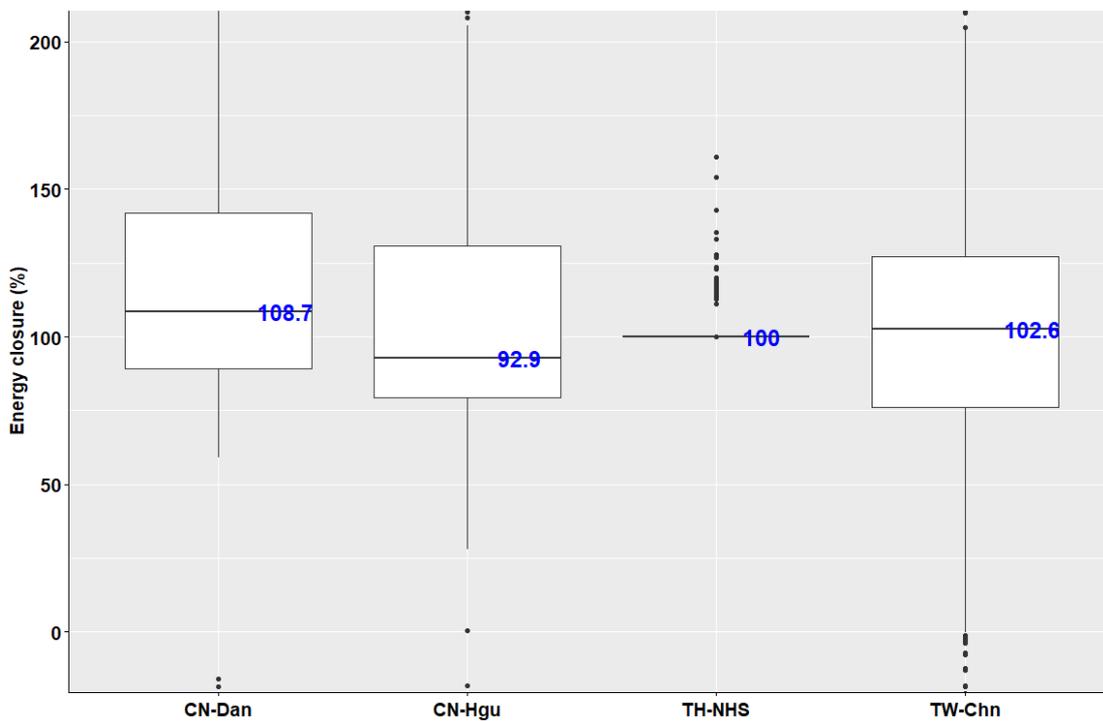


Figure R4. The distribution of energy closure at daily scale for four sites. The energy closure is calculated as $(LE + HS)/R_n * 100$. The labelled number is the median value of the distribution.

R2.6 L218: Clarify which parameters in the T&C model were calibrated.

Below are the main parameters we adjusted. We adjusted them to make sure the water, carbon, and energy fluxes are in reasonable agreement with the flux tower observations, as shown in Figure 2 in the manuscript and Figure S1, S2, and S3 in the supplementary material. We will add this Table in the Supplementary material in the revised article.

Table R1. Main parameters that need to be adjusted in T&C.

<i>Parameters</i>	<i>Unit</i>	<i>Description</i>
<i>age_cr</i>	<i>d</i>	<i>Critical leaf age</i>
<i>d_leaf</i>	<i>cm</i>	<i>Leaf characteristic dimension</i>
<i>dc_C</i>	<i>day⁻¹ °C⁻¹</i>	<i>Factor for increasing leaf turnover with cold</i>
<i>dmg</i>	<i>d</i>	<i>Phenology parameter days of maximum growth</i>
<i>drn</i>	<i>d⁻¹</i>	<i>Fine root turnover rate</i>
<i>fab</i>	<i>-</i>	<i>Fraction of aboveground sapwood and reserve</i>
<i>ff_r</i>	<i>-</i>	<i>Allocation parameter of fruit and reproduction</i>
<i>Knit</i>	<i>-</i>	<i>Canopy nitrogen decay coefficient</i>
<i>LDay_cr</i>	<i>h</i>	<i>Threshold for senescence: hours of light</i>
<i>LDay_min</i>	<i>h</i>	<i>Minimum day duration for leaf onset</i>
<i>Nl</i>	<i>gC gN⁻¹</i>	<i>Leaf carbon nitrogen ratio</i>
<i>r</i>	<i>gC gN⁻¹ d⁻¹</i>	<i>Maintenance respiration rate at 10 °C</i>
<i>Sl</i>	<i>m² gC⁻¹</i>	<i>Specific leaf area</i>
<i>Vmax</i>	<i>μmol CO₂ m⁻²s⁻¹</i>	<i>Maximum Rubisco capacity of 25 °C leaf level</i>
<i>ZR50</i>	<i>mm</i>	<i>50th percentile of root depth</i>
<i>ZR95</i>	<i>mm</i>	<i>95th percentile of root depth</i>
<i>ZRmax</i>	<i>mm</i>	<i>Maximum root depth</i>

R2.7 L285–286: I am not sure that the authors made an appropriate effort to find the carbon flux time series. For example, GPP of the MY-PSO site is shown as NA in Table 3 and Fig. S3, but the GPP time series in the same period (2003–2009) at the site is available in the FLUXNET2015 dataset. The dataset can be easily downloaded.

Thank you for pointing this out. We conducted a more thorough search of the available flux tower data and found more available GPP data for three sites: (a) ID-PDF, (d) MY-PSO, and (t) CN-Hgu. As shown in Figure R5, without further parameter adjustment, the T&C model still shows good performance in capturing GPP magnitude and seasonality. The new comparison will be included in the revised manuscript.

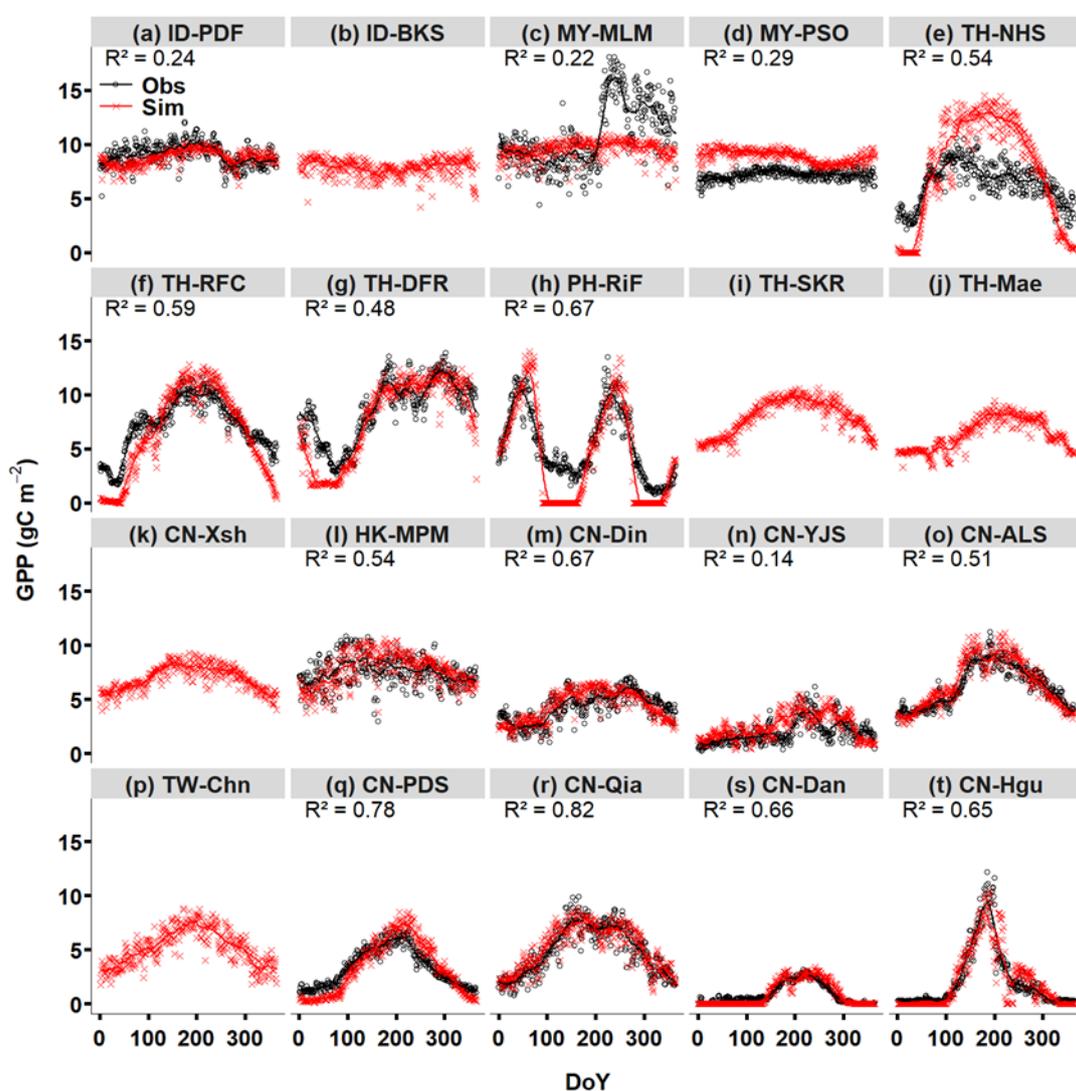
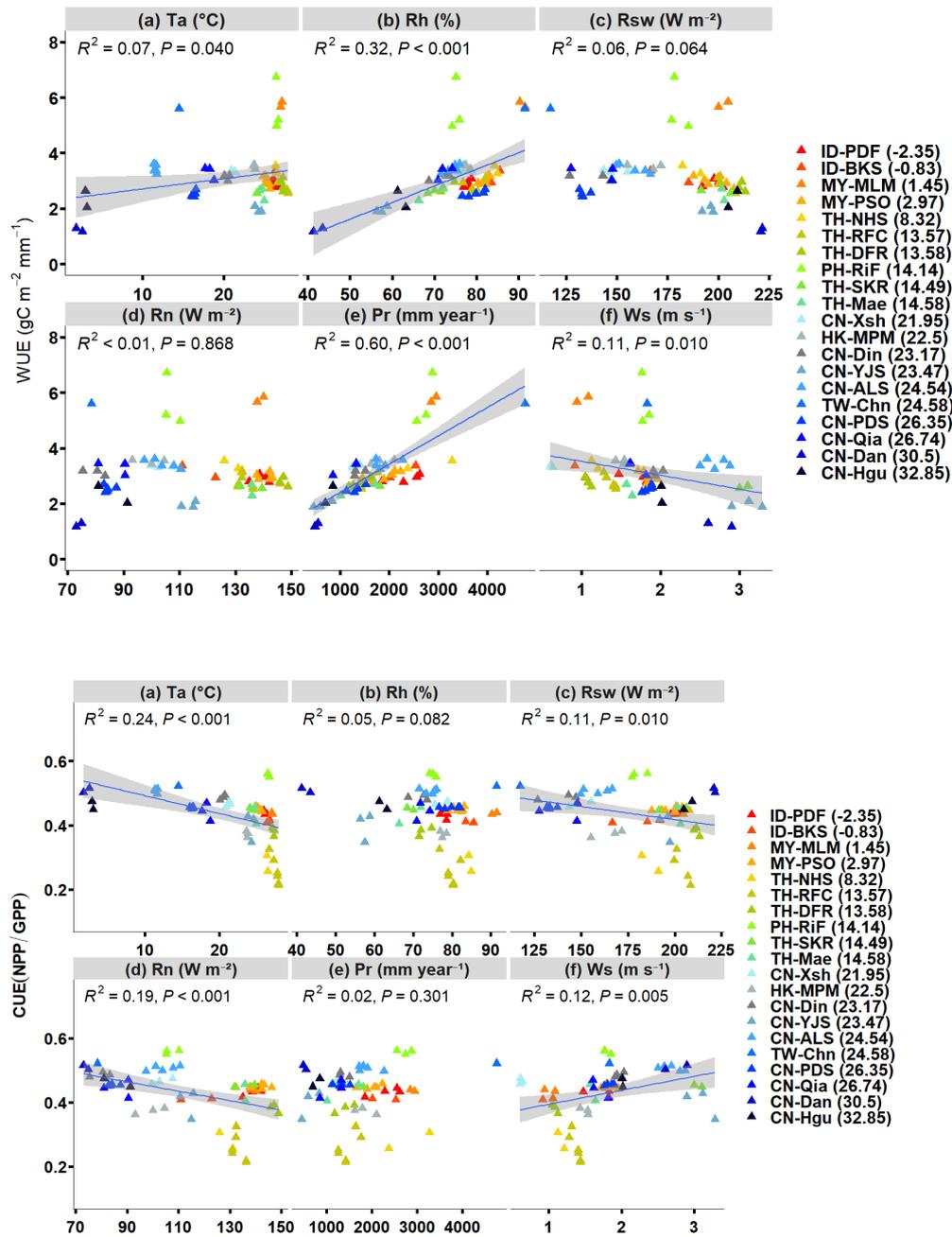


Figure R5. Comparison of the T&C model simulation with the GPP data from flux towers. The mean daily GPP is calculated for every day of year (DoY) considering all the years with observations. We also applied a moving average method with a window

of 30 days to calculate the smoothed seasonality (the continuous line) of observed and simulated GPP. The coefficient of determination of simulated vs. observed GPP at the daily scale is shown in the top left panel for each site.

R2.8 L362: It is recommended not to draw the regression line in Figs. 5, 6 if the p-value exceeds 0.05.

Thanks for the suggestion. We have revised Figure 5 and 6 as bellow for the revised manuscript.



R2.9 L444, 518, 563: Describe the meaning of the lines and shaded areas.

The solid line represents the fitted linear regression, and the shaded area indicates the 95% confidence interval of the estimated mean response. We will add this to the figure captions.

R2.10 L680: Include the information on the flux dataset source.

We added the sources of these data to the data availability statement, following the suggestion from the reviewer:

Data were mainly downloaded from <https://www.asiaflux.net/>, <https://fluxnet.org/>, and <https://www.sciengine.com/CSD/home>, and <https://zenodo.org> (last access November 2025). More specifically, we downloaded data for the stations ID-PDF (https://asiaflux.net/index.php?page_id=91), ID-BKS (https://asiaflux.net/index.php?page_id=38), MY-MLM (https://asiaflux.net/index.php?page_id=80), MY-PSO (https://asiaflux.net/index.php?page_id=93), TH-RFC (http://asiaflux.net/index.php?page_id=96), TH-SKR (http://asiaflux.net/index.php?page_id=102), TH-Mae (https://asiaflux.net/index.php?page_id=79), CN-Xsh (https://asiaflux.net/index.php?page_id=1174), TW-Chn (https://asiaflux.net/index.php?page_id=41), and CN-Qia (https://asiaflux.net/index.php?page_id=1177). Moreover, we downloaded data for the stations PH-RiF (<https://fluxnet.org/sites/siteinfo/PH-RiF>), HK-MPM (<https://fluxnet.org/sites/siteinfo/HK-MPM>), CN-Din (<https://fluxnet.org/sites/siteinfo/CN-Din>), CN-Dan (<https://fluxnet.org/doi/FLUXNET-CH4/CN-Hgu>). We also downloaded data from China Scientific Data for CN-YJS (<https://www.sciengine.com/CSD/doi/10.11922/csdata.2020.0057.zh>), CN-ALS (<https://www.sciengine.com/CSD/doi/10.11922/csdata.2020.0089.zh>), CN-PDS (<https://www.sciengine.com/CSD/doi/10.11922/11-6035.csd.2023.0063.zh>). The TH-NHS data was downloaded from Zenodo (<https://zenodo.org/records/6474361>).

Technical corrections:

R2.11 L134: Use “SEA” instead of “Southeast Asia”.

Noted and will do.

R2.12 L182: Use the exact name of the dataset (FLUXNET2015).

Noted and will do.

R2.13 L477, 482: Add “C” after “o”.

Noted and will do.

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