Response to Chaolei Zheng:

Dear reviewer, we sincerely appreciate your time and effort in reviewing our manuscript and providing valuable feedback to help improve our work. In the reply, the reviewer's comments are in black, our responses are in blue, and quotes from the revised manuscript are in *orange italics*.

I read the manuscript "A Globally Seamless Terrestrial Evapotranspiration Dataset Retrieved by a Nonparametric Approach with Remote Sensing and Reanalysis Datasets" with great interest. The new generated global ET data by RSNP model is a great contribution to the ET community. While the manuscript is generally well written and clear, I do have some specific comments and requests for clarification of the presented analyses.

ETMonitor ET dataset is seamless at daily resolution, and it even include open water evaporation and snow/ice sublimation in the terrestrial surface. I'm not sure exactly why the presented available ratio of pixels is low in some regions. It should be noted that extreme low ET value (e.g., zero) in ETMonitor product is valid, and the missing value is set as '-1' in the ETMonitor product. Please double check to make sure zero is not treated as unavailable data during the analysis.

Response: We sincerely appreciate your careful observation regarding the treatment of zero values in the ETMonitor ET dataset and we apologize for the error in our initial analysis about the ETMonitor ET dataset. ETMonitor ET dataset explicitly defines "-1" as missing data, while zero values over the global land surface are valid pixels. In the revised manuscript, we have corrected the statistical error by taking only '-1' as missing value in the ETMonitor product, and ETMonitor is seamless over the global land surface. The revised Figure 10 shows that ETMonitor has 100% available pixel ratios at the monthly scale, and the revised Fig.12 also shows ETMonitor's full spatial coverage. Thank you again for your valuable feedback, which has significantly improved the accuracy of our study.

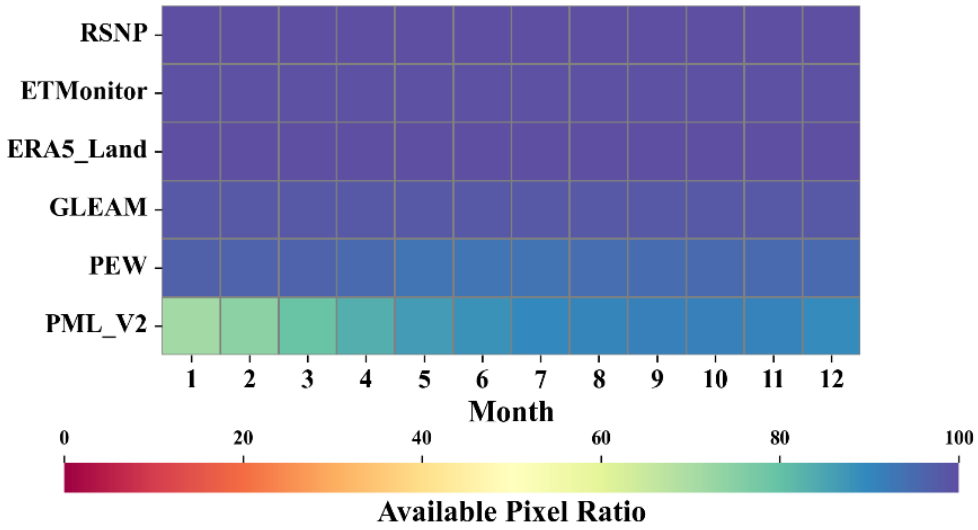

Figure 11: The available pixel ratio of ET datasets at the monthly scale

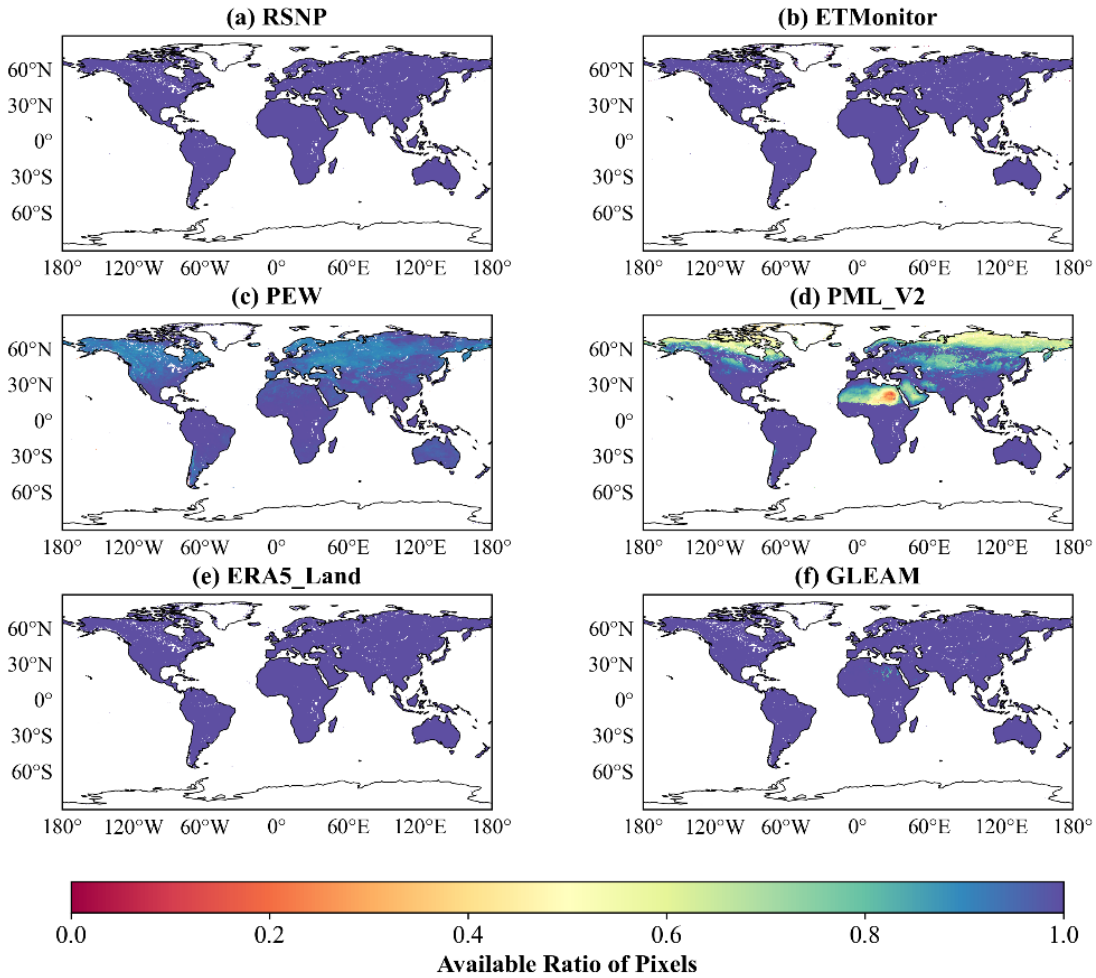

Figure 12: Spatial distribution of monthly ET pixels available ratio during 2003-2018 for global ET datasets (water, and permanent ice and snow were excluded).

The author mentioned the gaps in the desert regions specifically in the introduction. However, it should be noted that basic equilibrium assumption of SFE fails under the extreme condition, which will lead to large uncertainty. The RSNP model will suffer similar problem, since it combined SFE and NP. It's also noticed that all validation sites are located in the vegetation-covered regions and none locates in the desert or sparse vegetation regions, which cannot illustrate this problem. This also raises concerns about the reliability of the global seamless datasets in this study.

Response: We sincerely appreciate your valuable comments on the potential limitations of the SFE-NP method in arid regions. The current validation is indeed limited by the sparse distribution of FLUXNET2015 sites in dryland ecosystems. In our validation, there are three Australian grassland sites (AU-Stp, AU-Emr, and AU-TTE) from arid/semi-arid regions met our quality control criteria, whose validation results are presented separately in the following figure. As shown in the scatter plot, the SFE-NP method shows overestimations when observed ET was under 50 mm/month, but the performance with incorporating of relative humidity with the original NP method has been improved (Pan et.al, 2024). In future work, we will continue improving the accuracy of our NP approach, update the RSNP ET dataset, and incorporate additional validation from available arid region sites to enhance model performance.

Reference:

Pan, X., Yang, Z., Liu, Y., Yuan, J., Wang, Z., Liu, S., and Yang, Y.: A non-parametric method combined with surface flux equilibrium for estimating terrestrial evapotranspiration: Validation at eddy covariance sites, J. Hydrol., 631, 130682, http://doi.org/10.1016/j.jhydrol.2024.130682, 2024.

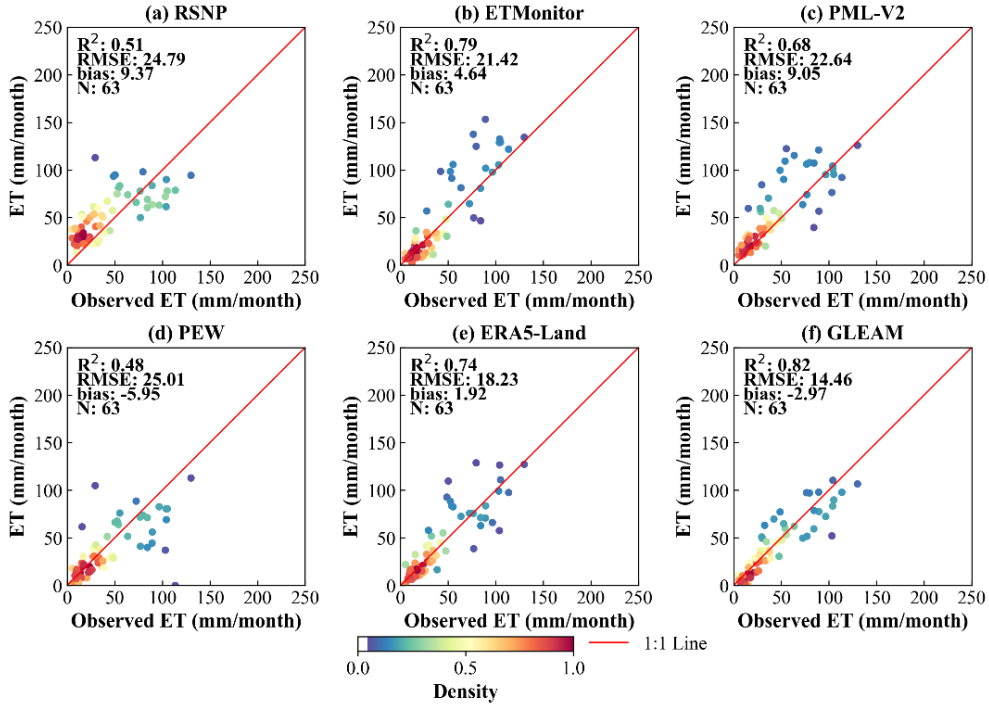

Figure: Comparison of estimated ET and observed ET over three FLUXNET2015 sites in arid region. The relative mean square error (RMSE) and the bias are both in mm/month.

Title: 'Globally' should be 'Global'.

Response: Thank you very much for your attention to detail. As suggested, we have revised the phrasing from "Globally" to "Global" in the title to ensure grammatical accuracy and consistency.

'Existing remote sensing models for estimating ET necessitate the parameterization of resistance parameters' does not mean a problem. Resistance can reflect the regulation of land surface or atmosphere status on ET effectively.

Response: We sincerely appreciate your comment regarding this statement in Abstract. As suggested, we have revised the original sentence to better indicate the gap between previous studies and this study, and the revise statement is as follows: "*Different parameterization schemes of resistances might result in uncertainties in global ET dataset.*" (Line 19). We hope the revised sentence would be much suitable and clear to connect the research goal of this study, and thank you again for helping us improve the clarity of our manuscript.

The RSNP model has been already published in other journals. It's unappropriated to say 'In this study, we proposed the Remote Sensed Non-Parametric (RSNP) model' in the abstract.

Response: We sincerely appreciate your careful reading and constructive comment regarding the description of the RSNP model in the Abstract. We fully acknowledge that the original wording could give the misleading that this was the first presentation of the RSNP model. To address this

misunderstanding, we revised this statement to "*In this study, we improved the Remote Sensed Non-Parametric (RSNP) model based on the NP and SFE-NP method, …*". (Line 21)

Does 'remote sensing and reanalysis datasets of meteorological and surface parameters' mean remote sensing dataset of surface parameters and reanalysis datasets of meteorological parameters?

Response: Thank you very much for your feedback on the description of input data. Upon careful consideration, we recognize that our original phrasing could indeed be misleading, as the ERA5-Land reanalysis dataset provides not only meteorological parameters but also land surface temperature data. To address this concern and improve clarity, we have revised the relevant sentence in the manuscript as follows:

"In this study, we improved the Remote Sensed Non-Parametric (RSNP) model based on the NP and SFE-NP method with remote sensing and reanalysis data, and developed global monthly ET from 2001 to 2019 in the spatial resolution of 0.1°.". (Line 21-23)

How many sites are used for validation?

Response: We greatly appreciate your valuable suggestion regarding the clarity of the validation sites. According to your suggestion, we have revised the Abstract to explicitly state that a total of 88 sites were utilized for validation in this study: *"Validation against 88 FLUXNET2015 sites globally…"* (Line 24)

Present the abbreviation when first appearance.

Response: Thank you very much for your valuable comments. We acknowledge that some abbreviations were not properly defined upon their first appearance in the original manuscript, which could potentially affect the clarity of our presentation. We have carefully reviewed the entire manuscript and made corrections. And thank you for helping us enhance the quality of our work.

Besides soil evaporation and vegetation transpiration, terrestrial ET also include evaporation from open water body and the canopy intercepted rainfall.

Response: Thank you very much for your comments regarding the components of terrestrial ET. To ensure the accuracy of this manuscript, we have revised the statement as "*Terrestrial evapotranspiration (ET), consisting of soil evaporation, vegetation transpiration, canopy rainfall intercept and open water evaporation.*" (Line 33-34). We appreciate again for your attention to this detail, which has helped us present a more complete and precise description of our study.

Line 53-54: improper citation.

Response: We sincerely appreciate your comments on the citation in our manuscript. We regret present such improper citation in the manuscript, and we have thoroughly revised the list of global ET dataset and reference for each product. The revised statement is as follows,

"Manny global ET datasets derived from remote sensing data and meteorological forcing data have been proposed, including MODIS-MOD16 dataset (Mu et al., 2011), Penman–Monteith–Leuning Version 2 (PML-V2) dataset (Zhang et al., 2019), the Operational Simplified Surface Energy Balance (SSEBop) dataset (Senay et al., 2020), Calibration-free (CR) dataset (Ma et al., 2021), ETMonitor dataset (Zheng et al., 2022), a simplified surface energy-water balance model based on proportionality hypothesis (PEW) dataset (Fu et al., 2022), three temperature (3T) dataset (Yu et

al., 2022) and so on.". (Line 54-59)

Reference:

Fu, J., Wang, W., Shao, Q., Xing, W., Cao, M., Wei, J., Chen, Z., and Nie, W.: Improved global evapotranspiration estimates using proportionality hypothesis-based water balance constraints, Remote Sens. Environ., 279, 113140, http://doi.org/10.1016/j.rse.2022.113140, 2022.

Ma, N., Szilagyi, J., and Zhang, Y.: Calibration-free complementary relationship estimates terrestrial evapotranspiration globally, Water Resour. Res., 57, e2021WR029691, https://doi.org/10.1029/2021WR029691, 2021.

Mu, Q., Zhao, M., and Running, S. W.: Improvements to a MODIS global terrestrial evapotranspiration algorithm, Remote Sens. Environ., 115, 1781-1800, http://doi.org/10.1016/j.rse.2011.02.019, 2011.

Senay, G. B., Kagone, S., and Velpuri, N. M.: Operational global actual evapotranspiration: Development, evaluation, and dissemination, Sensors, 20, 1915, https://doi.org/10.3390/s20071915, 2020.

Yu, L., Qiu, G. Y., Yan, C., Zhao, W., Zou, Z., Ding, J., Qin, L., and Xiong, Y.: A global terrestrial evapotranspiration product based on the three-temperature model with fewer input parameters and no calibration requirement, Earth Syst. Sci. Data Discuss., 2022, 1-33, https://doi.org/10.5194/essd-14-3673-2022, 2022.

Zhang, Y., Kong, D., Gan, R., Chiew, F. H., McVicar, T. R., Zhang, Q., and Yang, Y.: Coupled estimation of 500 m and 8-day resolution global evapotranspiration and gross primary production in 2002–2017, Remote Sens. Environ., 222, 165-182, http://doi.org/10.1016/j.rse.2018.12.031, 2019.

Zheng, C., Jia, L., and Hu, G.: Global land surface evapotranspiration monitoring by ETMonitor model driven by multi-source satellite earth observations, J. Hydrol., 613, 128444, https://doi.org/10.1016/j.jhydrol.2022.128444, 2022.

Line 62-63: This is not well connected to previous sentence, which address the problem of date gaps when applying to relevant studies.

Response: We appreciate your comments regarding the research gap in our study, and we sincerely apologize for the insufficient clarity in our initial writing. According to your comments, we have revised the statement to better connect previous researches and the previous study, which mainly focused on the contribution of the proposed physical-based global ET dataset:

"By evaluating 25 global ET datasets with site observations and their spatial patterns. Tang et.al refer that ET dataset produced based on similar algorithms tend to have high consistency in annual magnitude and spatial distribution (Tang et al., 2024). Therefore, developing a global ET dataset based on well-defined physical mechanisms remains a critical need in ET research. Moreover, integrating datasets with reliable accuracy and clear physical significance can enhance the robustness of analytical results in global data synthesis." (Line 68-74)

GLASS data provide Black sky Albedo and White sky Albedo, which blue sky albedo is need in Eq(2). How the author covert GLASS albedo to blue sky albedo?

Response: Thank you for your feedback on Eq.(2). In Eq.(2), blue-sky albedo is required, our study acquired blue-sky albedo as a weighted combination of black-sky albedo and white-sky albedo, and

the weighting factor used is the proportion of diffuse skylight to total solar radiation, consistent with the approach described by (Pinty et al., 2005). Additionally, we have now included the reference for the blue-sky albedo calculation in the revised manuscript (Line137).

Reference:

Pinty, B., Lattanzio, A., Martonchik, J. V., Verstraete, M. M., Gobron, N., Taberner, M., Widlowski, J.-L., Dickinson, R. E., and Govaerts, Y.: Coupling diffuse sky radiation and surface albedo, J. Atmos. Sci., 62, 2580-2591, https://doi.org/10.1175/JAS3479.1, 2005.

Table 1 should be reorganized, and some listed datasets are not model forcing.

Response: We sincerely thank you for your comment on the classification of Figure 1. According to the reorganize of our manuscript, the revised Table 1 contains only model forcing data, and we have added a column of "Data Type" to distinguish which input is from remote sensing and which from reanalysis. The revised Tabel 1 is presented as follows:

Table 1 Remote sensing and reanalysis datasets used in the RSNP model

Dataset	Data Type	Variables	Spatial resolution	Temporal resolution
GLASS	Remote sensing data	Black sky Albedo White sky Albedo Broadband Emissivity (BBE)	0.05°×0.05°	8-day
ERA5-Land	Reanalysis data	Skin temperature Surface pressure Downward longwave radiation Downward shortwave radiation 2m Temperature 2m Dew point temperature	0.1°×0.1°	Monthly
MCD12Q1The water-balance-based ET on dataset of large river basins of the world	Reanalysis data	Land cover type	1 km×1 km	Annual
Version 3 of the Global Aridity Index and Potential Evapotranspiration Database	Reanalysis data	Aridity Index	1 km×1 km	

Please describe the quality control process for flux tower data.

Response: Thank you for your feedback on the introduction of flux tower data, and your suggestion helps us to improve the clarity of our manuscript. According to your suggestion, we have expanded the quality control pross of FLUXNET2015 flux tower data from two aspects. Firstly, we introduced the energy balance closure correction of FLUXNET2015. In addition, we expanded the energy balance closure rate selection statement. The revised statement is presented as follows:

"ET observation offered from FLUXNET2015 were corrected by energy balance closure correction factor (Pastorello et al., 2020). Qualified observations were utilized for validation, including with

an energy closure rate (Rn-Gs/LE+Hs) ranging between 0.8 and 1.0, along with at least five consecutive months of valid data.". (Line 175-178)

Reference:
Pastorello, G., Trotta, C., Canfora, E., and Papale, D.: The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data, Nature Publishing Group, https://doi.org/10.1038/s41597-020-0534-3, 2020.

To sample from 500m or 1km to 10km, the average resampling method should be adopted.

Response: Thank you for your valuable feedback regarding the resampling methodology in our model input data. We fully recognize the importance of using appropriate resampling techniques, especially when scaling from higher resolutions to lower resolutions. In future versions of our dataset, we will prioritize the implementation of the average resampling method for resamples from high to low resolution. This approach will help us achieve a more accurate and representative spatial distribution, ensuring the ET dataset better supports its applications and analyses. We appreciate your again for the important suggestion on our data development.

The coefficients in Eq(3) are wrong. According to GLEAM, it should be 0.25 for bare soil and 0.05 for tall canopy. Please double check the model application.

Response: Thank you very much for your comment on Eq(3). We sincerely apologize for the incorrectly wrote the coefficients in Eq(3), and we deeply regret any confusion may have caused. Through verification of the model application, we confirm that it was only the miswriting in the manuscript, and we have revised the coefficients as following:

$$G_s = \begin{cases} 0.05R_n & tall\ canopy \\ 0.20R_n & short\ vegetation, \\ 0.25R_n & bare\ soil \end{cases} \quad (3)$$

Thank you again for catching this important error and helped us to improve the accuracy of our manuscript.

Eq(5): Different equation should be adopted to estimate water vapor pressure when the surface is covered by snow/ice (either permanent or temporarily).

Response: Thank you very much for your insightful comments and suggestions. We truly appreciate the suggestions particularly regarding the potential improvements in the accuracy of our ET product across different land covers. Your suggestions will be carefully considered in our future work as we strive to enhance the robustness and applicability of our methods. In addition, according to the Reviewer 1's suggestion, the Eq.(4) and Eq.(5) have been removed from the revised version of the manuscript, because they are not the key method of RSNP model for ET estimation.

Line 154: '0.05°' -> '0.1°' ?

Response: Thank you for your helpful comments. We are sorry for the mistake in this sentence, because the 0.05° GLASS were resampled to 0.1° instead of 0.05°, and we have revised this error. "*And finally, the gap-filled global albedo and BBE, and global aridity index datasets were resampled to 0.1° using the nearest neighbor resampling.*" (Line 156-157)

Section 3.2 mixes too much information, and it is recommended to reorganize it. The framework of ET estimation should be moved to somewhere in the front, rather than the last part. The processing of BBE should move to the data Section.

Response: Thank you for your suggestion on improving the manuscript structure. We have reorganized the content accordingly, and the revised Section2 covers the method and data. Section 2.1 provides an expanded introduction to the NP and SFE-NP methods. Section 2.2 presents the ET estimation framework along with model forcing data, followed by the gap-filling process in its final paragraph. Section 2.3 contains datasets used for model evaluation. We believe these modifications have improved the logical flow and clarity of the methodology section.

The structure of Section2 is as follows:

2.Methodology and Materials

2.1 Nonparametric approach for global ET Estimation

2.2 Framework of Global ET Estimation and Model Forcing Data

2.3 Datasets for Evaluation

2.3.1EC Observations from FLUXNET2015

2.3.2Water-balance-based ET of Global Basins

2.3.3Other Global ET Datasets

The footprint of the flux tower observation mismatch the 0.1°pixels as the estimated ET, and the relevant uncertainty should be noticed.

Response: We appreciate your important suggestion about the mismatch caused by the footprint of flux tower, and we have added statement to mention this issue at Section2.3, together with the validation flow: *"While the mismatch between observational footprints and 0.1° pixel dimensions could lead to uncertainties in in-situ assessment (Liu et al., 2016), RSNP annual ET were evaluated with water-balance based ET at basins to access the model's effectiveness for the regional scale."*(Line 163-165).

Additionally, we also added discussion in Section 4.2 to discuss the potential uncertainties in previous work: *"It is important to note that EC observations represent the footprint scale, which differs from pixel-scale estimations. To address this discrepancy, upscaling methods could be further employed to effectively overcome the mismatch between these scales."* (Line 401-403)

Line 185: Correlation Coefficient is generally expressed as R, not R2. Please also check this citation.

Response: We sincerely appreciate your thorough review of our manuscript. In the initial version, we erroneously used the term "Correlation Coefficient" to refer to R^2. We have corrected "Correlation Coefficient" to "Coefficient of Determination" in the revised manuscript, which infers to R^2. (Line 169)

Line 204: precision indicators?

Response: Thank you for your comment regarding the term "precision indicators." We have revised this to "statistical metrics" to improve clarity in the context of our manuscript. (Line 167)

Line 206: 'valud'?

Response: We sincerely thank you for your careful review. The incorrect spelling of the word has been corrected as 'value'. (Line 245)

Line 227: ‘arid index is over 1.0’ means arid or humid?

Response: We sincerely appreciate your feedback regarding this statement. The ‘arid index over 1.0’ indicates humid basin, but according to the discussion only one data point exceeded 1.0 lacked statistical significance. Consequently, the single point was insufficient to reliably demonstrate the model's performance in humid regions. Therefore, we have removed the related statement from the manuscript. Thank you once again for your valuable feedback.

Section 4.3.1: how to estimate the global average ET if the dataset is not seamless?

Response: Thank you for your insightful feedback on the global ET statistics. We treated gap value as 0 ET values over the global land surface for calculating the global averages.

Discussions: Please double check the issue of missing values (see my above comments) and revise it accordingly. The estimated daily ET in the desert is generally very small (but still larger than 0). However, to save the disk storage, the ET data is stored in integer format (rather than float point format) after multiplying by a scaling factor, which is common when publishing the high-resolution data. Consequently, those very small ET value may be stored as zero in the published dataset, which is still valid.

Response: We sincerely appreciate your comments regarding the statistics of missing values. We acknowledge that we made an error in our initial analysis by incorrectly treating zero ET values in the ETMonitor ET dataset as invalid pixels, when in fact they represent valid and very small ET value in low ET regions. We have carefully revised statistics in Section 4 to address this issue:

(1) In Section4.1, we only take ‘-1’ as invalid pixels for ETMonitor, and the revised available pixel value of ETMonitor ET dataset was approximately 100% over global land surface at the monthly scale. We have revised relative discussions and Fig.11 and Fig.12.

(2) In Section4.1, we have also added potential reasons for zero ET values in high resolution datasets to provide a more comprehensive explanation:
“Nevertheless, the potential reason for 0 value in high spatial resolution global ET dataset (such as ETMonitor) is related to the storage of integer format, while low ET value may be stored as 0 value rather than missing values should be mentioned.” (Line 346-348)

There is no evidence or quantitative assessment on how the gaps impact the water resources or water-energy-carbon nexus in this study.

Response: We sincerely thank you for your comments regarding this statement. We apologize for the missing period after the reference, which caused ambiguity in the sentence. We have revised this statement: *“Furthermore, the water-energy-carbon nexus in these regions is highly susceptible to climate variability (Park et al., 2020). Incomplete data may make it crucial to have comprehensive data to ensure a precise understanding of ecological, environmental, meteorological, and hydrological shifts.”*. (Line 354-357)

Line 336-340: This is important, but need a more comprehensive discussion.

Response: We sincerely appreciate your valuable feedback regarding the need for a more comprehensive discussion on this important point. In response to your suggestion, we have carefully revised and expanded the relevant discussion as follows:

"However, incorporating datasets faces a fundamental challenge which result from datasets sharing similar theoretical frameworks tend to exhibit correlated systematic biases (e. g. PM equation, PT equation, surface energy balance residual methods). For instance, PM based models are sensitive to parameterization methods of canopy and soil resistance, PT based models show biases in fixing PT coefficient, energy balance models inherit uncertainties with aerodynamic resistance. Conversely, the RSNP based on Hamiltonian principle and remains a diagnostic model independent from empirical resistance or calibration and is helpful for eliminating uncertainties in global terrestrial water-energy budget researches." (Line392-399)