Reply to Referee #3’ s comments

Title: A flux tower site attribute dataset intended for land surface modeling
No.: essd-2024-77

Shi et al. improve an existing flux tower dataset developed for land modelling. These efforts are very valuable for the land modelling community and as such it was a pleasure to read this paper. I fully agree with the authors on the need to provide improved ancillary data for modelling and commend the authors' efforts in collating data on key variables which is not a simple task. This is a valuable contribution to the field, but I do have a few comments I would ask the authors to consider:

Thank you for your careful evaluation of this manuscript. We greatly appreciate your positive and constructive comments on our manuscript, which have significantly improved its quality.

All comments are addressed on a point-by-point basis below. The comments are presented in italicized font and specific concerns are numbered. Our response is given in normal font. The list of all related changes is given in blue text.

Comment 1: *I feel this paper is somewhat a missed opportunity by applying the quality control process to PLUMBER2 rather than taking the PLUMBER2 framework and applying it to newer releases of flux tower data. The datasets used in PLUMBER2 are now quite out-of-date and it would have been fantastic to see an update that incorporates newer data and possibly additional sites (e.g. from ICOS and data from individual networks)*

Response 1: Thank you for your careful evaluation of this manuscript. We acknowledge the importance of including additional sites such as those from ICOS and individual networks. This has also given us new ideas.

PLUMBER2 includes the major datasets since the release of flux tower data. However, since flux tower datasets like FLUXNET2015 have not been released in new versions, PLUMBER2 does not contain observational data updated in recent years. Nevertheless, the site data included in PLUMBER2 continues to serve as a valuable resource for future research.

Our work also provided a framework and makes it convenient to add more sites. All the code and related data are publicly available. New flux tower data and sites will continue to be updated in the future. This is indeed a valuable direction for future research.

Comment 2: *I would be cautious to only provide one LAI product. In the PLUMBER2 paper we found very large differences in LAI from the MODIS and Copernicus products at some sites. A comparison to max LAI is provided in the paper but the time evolution of MODIS and Copernicus can also be very different. I would strongly encourage the authors to also consider alternative LAI products. It was also unclear how the MODIS data was processed?*

Response 2: Thank you very much for your suggestions. We fully acknowledge that there can be significant differences among various satellite LAI products, as demonstrated by numerous LAI products and papers.

We have chosen only the reprocessed MODIS LAI product in our study. An important reason is that the reprocessed MODIS LAI product has been extensively validated and applied in many studies (especially within the land modeling community), making it more familiar to researchers. Thus, it serves as a valuable reference. Additionally, to show the uncertainty of the reprocessed MODIS LAI, we have quantified it using site LAI (Response 13), which will offer readers a reference for understanding the uncertainty involved.

We apologize for the lack of description regarding the reprocessed MODIS LAI. Revisions have been made based on your suggestions.

Origin (L89):

"And the reprocessed MODIS LAI is much smoother and more consistent with adjacent values, displaying better spatiotemporally continuous and consistency."

Revised (L89):

"The reprocessed MODIS LAI used the modified temporal spatial filter (mTSF) method for a simple data assimilation, then applied the post processing-TIMESAT (A software package to analyze time-series of satellite sensor data) Savitzky–Golay (SG) filter to get the final result. Site LAI validation shows that the reprocessed MODIS LAI is much smoother and more consistent with adjacent values than the original MODIS LAI, and closer to site observations (Lin et al., 2023; Yuan et al., 2011)."

Comment 3 (L13): *Can you mention an example here of what you mean by "site-observed attribute data"?*

Response 3: Thank you for your valuable feedback. We have added examples to illustrate "site-observed attribute data".

Origin (L13):

"More importantly, these datasets lack site-observed attribute data, limiting their use as benchmarking data."

Revised (L13):

"More importantly, these datasets lack site-observed attribute data, such as fractional vegetation cover and leaf area index, which limits their utility as benchmarking data."

Comment 4 (L18): *Please check grammar here, wording unclear*

Response 4: Thank you for your correction. We have corrected the grammar.

Origin (L17):

"Then we obtained the final flux tower attribute dataset by global data product complement and plant functional types (PFTs) classification."

Revised (L17):

"We then obtained the final flux tower attribute dataset by filling in missing data with global data products and classifying plant functional types (PFTs)"

Comment 5 (L41): *would be good if you could mention some examples of "poor quality data" and "deficiency of attribute data" to make this a bit more concrete*

Response 5: Thank you for your suggestions. Here, we use "poor quality data" and "deficiency of attribute data" to lead into the following two paragraphs. The following two paragraphs are specific introductions of "poor quality data"and "deficiency of attribute data", respectively. We are unsure if this approach is logically coherent. If you have any other ideas, please feel free to share your suggestions.

Comment 6 (L53): *The reason for not screening flux data for gapfilling was that the requirements around this can be very study-specific. Some research questions might need high quality multi-year records whereas others might concentrate on individual events. This is just a comment but screening for flux gapfilling is challenging when creating a dataset for general use.*

Response 6: We fully agree with your opinion. Other reviewers have also suggested retaining more data and years. In response to this, we provide a more detailed description of each excluded year, labeling whether the exclusion is due to the poor quality of flux, meteorological variable, or both.

We will add this information to Tables S2 and S3 in the manuscript submission after the Discussions. This will allow users to get more detailed data quality information and to choose simulation years and assessment variables according to their individual needs. Users can easily obtain the complete set of variables and time series from PLUMBER2.

Comment 7 (L55): *Yes this is often the case but there are also many studies relying on site-specific information where this is available. Often this is done out of necessity as you point our on L67*

Response 7: Thank you for your correction. It is true, as you say, that there are also many studies relying on site-specific information where this is available. We've revised the wording based on your suggestion.

Origin (L56):

"the current practice involves deriving these attribute data"

Revised (L56):

"the current practice usually involves deriving these attribute data"

Comment 8 (L75): *No argument that these are important but can we really state that they are the most important attributes?*

Response 8: Thank you for your suggestion. We agree that determining the "most important" attributes can be subjective and may vary depending on the specific context and criteria used for evaluation. To provide a more balanced view, we have revised the text to express that these data are fundamental attributes needed for modeling.

Origin (L75):

"Furthermore, by modeling for the four most important attribute variables—percentage of plant functional type (PFT) cover (PCT_PFT), LAI, canopy height and soil texture—we demonstrate how the site-observed attribute data and the conventional attribute data used by LSMs differ in their model output. These results emphasize the non-negligible impact of flux tower attribute data in model simulation and its development."

Revised (L75):

"Furthermore, through modeling comparison for the four attribute variables—percentage of plant functional type (PFT) cover (PCT_PFT), LAI, canopy height, and soil texture—we demonstrate how the site-observed attribute data and the default attribute data used by a LSM differ in their outputs. These results emphasize the impact of flux tower attribute data on model simulations and development."

Comment 9 (L87): *It is not clear how the Köppen-Geiger classification helps with LSM modelling?*

Response 9: Thank you for your suggestion. In this study, the 16 PFT classifications include climate types of vegetation (e.g., tropical, temperate, and boreal). The Köppen climate classification corresponds to these vegetation climate types and is therefore used for PFT classifications. Here (L87), we mainly introduce the data used without the specific methods. However, we have provided a more detailed description of the methods (Response 25).

Comment 10 (L90): *MODIS v6.1 might be better but uncertainties in remotely sensed LAI can be huge. PLUMBER2 provides two independent LAI for this reason as at some sites LAI estimates are vastly different. I'm not sure providing an estimate from a single dataset is helpful or superior. If anything, it would have been valuable to include more LAI datasets to account for uncertainty and constrain these with site observations where available*

Response 10: Thank you for your comments regarding the uncertainties in remotely sensed LAI. We believe the value of using multiple LAI datasets to account for uncertainties in remotely sensed data. Here, we chose to utilize the reprocessed MODIS v6.1 LAI and use the site LAI to quantify its uncertainty. Please refer to response 2 for specific treatment. Please also see Comment 2 for more information.

Comment 11 (L90): *Can the authors demonstrate that the data is smoother and more consistent? It is also not documented how this data was processed. Taking the raw values without additional quality control is rarely sufficient*

Response 11: Thank you for your suggestions. To provide a clearer introduction to the reprocessed MODIS LAI, we have added a summary of the processing methods along with the relevant citations. The comparison before and after modification is as follows:

Origin (L89):

"And the reprocessed MODIS LAI is much smoother and more consistent with adjacent values, displaying better spatiotemporally continuous and consistency."

Revised (L89):

"The reprocessed MODIS LAI used the modified temporal spatial filter (mTSF) method for a simple data assimilation, then applied the post processing-TIMESAT (A software package to analyze time-series of satellite sensor data) Savitzky–Golay (SG) filter to get the final result. Site LAI validation shows that the reprocessed MODIS LAI is much smoother and more consistent with adjacent values than the original MODIS LAI, and closer to site observations (Lin et al., 2023; Yuan et al., 2011)."

Comment 12 (L93): *please check grammar*

Response 12: Thank you for your suggestions. We have revised it.

Origin (L93):

"LAI complements still use the reprocessed MODIS LAI. FVC complements use a global 300m PFT map"

Revised (L93):

"LAI filling still uses the reprocessed MODIS LAI, whereas the FVC filling employs a global 300 m PFT map"

Comment 13 (L95): *Were these PFT estimates cross-checked against site information e.g. from past papers? Global PFT datasets can be highly uncertain at flux towers even if provided at a high spatial resolution*

Response 13: We completely agree with your suggestion. Other reviewers have raised similar concerns, indicating the need for cross-checking of filled data to quantify their uncertainties.

Accordingly, we have provided the quantification of uncertainties for the filled data. The discrepancies between site data and filled data have been added to Sect. 3.2, illustrating the uncertainties of the filled data. The added part is as follows:

Add (Sect. 3.2):

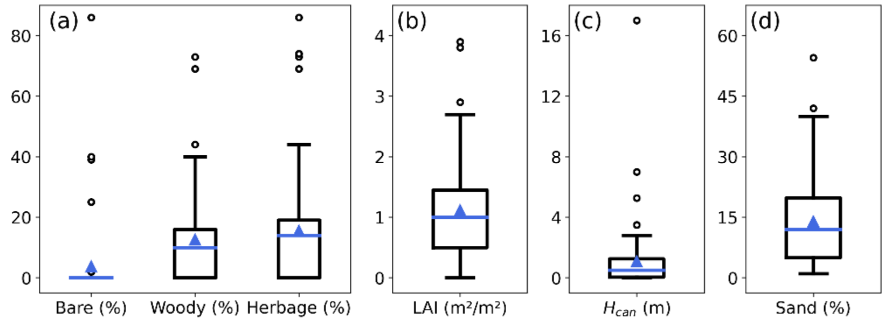

Figure 4. Quantification of discrepancies between site data and filled data for (a) PCT_PFT, (b) maximum LAI, (c) canopy height, and (d) percentage of sand (at all sites for which both types of data are available). The 16 PFTs were divided into three main categories (bare soil, woody, and herbage) for separately quantification.

Add (L299):

Figure 4 quantifies the differences between site data and filled data at all sites for which both data sources are available, illustrating the inhomogeneities in the final dataset due to data filling. The differences in vegetation cover (including bare soil, woody, and herbaceous vegetation) generally fall within 20%, with a minority of sites exceeding 40%. The mean and median LAI differences are approximately 1 m^2/m^2. Canopy height deviations are primarily within 2 m, although a few sites exceed 4 m. Differences in sand content typically remain within 30%, with both mean and median differences below 15%. This quantification indicates that the filled data are generally reliable across most sites.

Comment 14 (L99): *It is a little unclear how it is helpful providing soil type estimates using a dataset already applied in LSMs. As the authors state at the start, the use of such global datasets in flux site simulations risks discrepancies in model-obs comparisons*

Response 14: Thank you for your suggestions. We agree with you that global soil types do not offer obvious benefits in site-specific simulations. Therefore, the use of soil type estimates from these datasets is primarily to provide a reference. Additionally, following your recommendation, we have conducted cross-validation of these data (as detailed in Response 13), which enhances their reference value and reliability.

Comment 15 (L104): *noting that elevation was provided in PLUMBER2*

Response 15: Thank you for your correction. Since the topography data was added later, we apologize for not having noticed this. We have removed the description of elevation.

Origin (L106):

"The topography attributes included elevation, slope, and aspect."

Revised (L106):

"The topography attributes included slope and aspect."

Comment 16 (L109): *breakdown -> broken down*

Response 16: Thank you for your correction. We have revised it based on your suggestion.

Origin (L109):

"the FVC was further breakdown to different PFTs"

Revised (L109):

"the FVC was further broken down into different PFTs"

Comment 17 (Figure 1): *"Data complement" is not entirely clear, do you mean supplementing site obs with global datasets?*

Response 17: Thank you for your question. We apologize for the ambiguity. "Data complement" indicates site measurements gap-filled with global datasets. we have changed the wording to express it more clearly.

Origin (Figure 1):

"Data complements"

Revised (Figure 1):

"Data filling"

Comment 18 (L122): *Would be good to justify why (1) was done? On L133 you say non-consecutive years were kept to maximise utility of obs data, this somewhat contradicts that principle?*

Response 18: Thank you for your question. Observational data of only one year are generally unstable or unreliable. Consequently, we implemented step (1). Although subsequent screening resulted in some sites having only one year of data that meets the standards, this data is still considered stable. We have revised (1) to clarify this point.

Origin (L122):

"Sites with only one year of observations were excluded."

Revised (L122):

"Sites with only one year of observations were excluded for data stability and reliability."

Comment 19 (L123): *As mentioned earlier, is this desirable, restricting how the data can be used for individual applications?*

Response 19: Thank you for your suggestions. We fully agree with your opinion. For individual research, this excluded data could also be very useful. Therefore, we have provided users with the opportunity to access this data. Please refer to response 6 for specific treatment.

Comment 20 (L126): *ideally the VPD screening should be done in conjunction with temperature screening as both were used to convert VPD to specific humidity. A very good point that PLUMBER2 only used temperature but not VPD gapfilling information when screening specific humidity data*

Response 20: Thank you for your comment on the need to screen VPD. We are also grateful for your responsiveness to our questions in using PLUMBER2.

Comment 21 (L127): *These sites still provide non-corrected latent heat. It is not clear whether the EBF-corrected data is "better" (see https://egusphere.copernicus.org/preprints/2024/egusphere-2023-3084/)*

Response 21: Thank you for pointing out the availability of non-corrected latent heat. The non-closure of energy balance in eddy covariance (EC) flux tower observations has been a persistent issue and the subject of extensive discussion. Nevertheless, it is undeniable that the non-closure of the surface energy balance is one of the greatest challenges in quantifying the atmosphere-surface exchange of energy and water (Zhou et al., 2023).

The reasons for the energy imbalance are not attributable to a single factor. Different causes of imbalance may require different correction methods (Mauder et al., 2020). Overall, the Bowen ratio closure method demonstrates better performance compared to other closure methods (Zhou et al., 2023). Therefore, it can be said that applying the Bowen ratio for energy balance closure is generally advantageous in most cases.

We appreciate your thoughtful comments and hope these replies satisfy you.

Comment 22 (L140): *I don't quite follow this?*

Response 22: Thank you for your question. We appreciate the opportunity to clarify this point. In our study, we aimed to include as many site-observed data as possible. For sites where FVC data was missing, we used values close to the FVC as replacements, including the percentage of vegetation flux footprint contribution and dense forest canopy basal area. We treated them as FVC in this paper.

We have changed the wording to express it clearly. The comparison before and after modification is as follows:

Origin (L140):

"For sites lacking a direct FVC representation but providing information on the percentage of vegetation flux footprint contribution or dense forest canopy basal area"

Revised (L140):

"For sites lacking FVC data but providing the percentage of vegetation flux footprint contribution or dense forest canopy basal area"

Comment 23 (L143): *please check grammar*

Response 23: Thank you for your correction. We have revised it.

Origin (L143):

"In the case of grassland and cropland sites, both surface cover landscapes are usually homogeneous cover and manual management."

Revised (L143):

"In the case of grassland and cropland sites, the vegetation cover type typically exhibits a high degree of homogeneity."

Comment 24 (L148): *is this really true?*

Response 24: Thank you for your question. This approach does indeed involve some uncertainty. However, due to the lack of more detailed data, we adopted this simple assumption. A similar approach was used by Bonan et al. (2002), where they considered that bare ground might not be present even in semiarid regions with sparse, yet homogeneous land cover.

Comment 25 (L150-156): *All of this needs further details, I don't follow how these steps were done*

Response 25: Thank you for your suggestions. We have added more detailed descriptions of these steps to ensure clear and comprehensible. We hope these revisions meet your satisfaction.

Origin (L149):

"For data completeness, we used the PFT_{local} maps to complement the data for sites lacking site-observed vegetation cover proportion. After that, we further breakdown the FVC data in terms of different PFTs to align with the requirements of LSMs simulation using PFTs. First, trees and shrubs were classified as evergreen or deciduous, as well as coniferous or broadleaf types, based on the vegetation type expressed in the data sources. Next, Köppen-Geiger climate classification maps are employed to categorize the climate type of PFTs using the method proposed by Poulter et al. (2011). To better represent the C3 and C4 grasses, we prioritize segmentation based on the data source descriptions. If site description was not available, then segmentation was performed using the Still et al. (2003) method, which uses flux tower air temperature, precipitation, and reprocessed MODIS Version 6.1 LAI. "

Revised (L149):

"After that, trees and shrubs were classified as evergreen or deciduous, coniferous or broadleaf, based on the vegetation type. As an example, eucalyptus trees are classified as evergreen broadleaf trees. For data completeness, we used the PFT_{local} maps to fill in data for sites lacking site-observed FVC.

We further break down the FVC into PFTs to meet the requirements of LSM simulations using PFTs. The breakdown method is as follows: First, the climate type of PFT was determined according to the Köppen climate classification (Poulter et al., 2011). Then, C3 and C4 grasses are partitioned using site descriptions. If site descriptions are unavailable, flux tower air temperature, precipitation, and the reprocessed MODIS LAI are used to calculate LAI proportions under C3/C4 climatic conditions, to estimate the C3/C4 grass proportions (Still et al., 2003)."

Comment 26 (L171): *It would have been valuable to use these site-observed values to constrain remotely-sensed (MODIS) LAI, was this step done? It would provide a useful guide as to how reliable the MODIS estimates are*

Response 26: Thank you for your question. In Section 2.3, for the modeling assessment of attribute data, we scaled the MODIS LAI time series using site-observed maximum LAI value.

Based on your comments, we decided to add an explanation in Section 2.3 about using site data, detailing how these site attributes were applied in the simulations. The added information is as follows:

Add (L225):

"In the site data simulations, we scaled the default LAI time series using maximum LAI, corrected the default canopy height using site canopy height, and replaced the default topsoil texture (0-28.9 cm) with site soil texture. For sites with multiple PFTs, we calculated the LAI for each PFT using growing degree days and PCT_PFT (Lawrence and Chase, 2007). Canopy height was classified into three groups based on PFT (trees, shrubs, or grassland), with site data used to adjust the default values for the corresponding group, while the other two groups retained their default values."

Comment 27 (L195): *elevation was provided for each site in PLUMBER2 so how is this an advance?*

Response 27: Thank you for your question. The topographic data was initially not included in the attribute dataset but was added at a later stage. This resulted in our neglect of elevation in PLUMBER2. We apologize for this. The elevation data provided here is essentially consistent with that in PLUMBER2. We have revised the relevant descriptions accordingly.

Origin (L194):

"The topography data encompasses site elevation, slope and aspect. These data are gathered from site descriptions in literature, regional networks, FLUXNET and AmeriFlux BADM files. Specifically, we acquired elevation for 89 sites, slope for 57 sites, and aspect for 49 sites from these reference sources. In the AU-Lit site, where site elevation data was unavailable from the aforementioned references, we used the elevation given in Ukkola et al. (2022)."

Revised (L194):

"The topography data encompass slope and aspect measurements. These data are gathered from site descriptions in published literature, regional network, FLUXNET and AmeriFlux BADM files. Specifically, we acquired slope measurements for 57 sites, and aspect information for 49 sites from these reference sources."

Comment 28 (L203): *This was also provided in PLUMBER2, would be interesting to know if the authors identified different heights to what was reported?*

Response 28 (L203): Thank you for your question. We have noted that PLUMBER2 provides reference measurement heights. Here, the attribute dataset provides the reference measurement height for wind speed. We observed that its values are generally consistent with the reference measurement heights in PLUMBER2 at most sites, with minimal differences. Additionally, following the suggestions of other reviewers, we have included the reference measurement heights for air temperature and humidity in the attribute dataset.

Comment 29 (L225): *these are not really climate variables?*

Response 29: Thank you for your correction. these variables are indeed directly used when describing climatic conditions. We have revised it.

Origin (L225):

"The discrepancy of site data relative to default data is compared by an ensemble of climate-related variables, including…"

Revised (L225):

"The discrepancy of site data relative to default data is compared by variables related to land surface energy, water, and photosynthesis processes, including…"

Comment 30 (L227): *Runoff is not available at flux sites so I don't follow how it was used?*

Response 30: Thank you for your question. Yes, there is a lack of observations of TR and a limitation in the observational depth of SWC.As mentioned in Eq (1), for SWC and TR, we did not use observational data but relied on simulation results to show their differences.

Comment 31 (L229): *grammar*

Response 31: Thank you for your correction.

Origin (L228):

"To quantify differences between output from the site and default data, and considering the seasonal fluctuations in the impacts of soil and vegetation on climate-related variables (Dirmeyer, 2011; Forzieri et al., 2020). We designed a statistical indicator called the percentage of mean difference (MD %) (Eq. 1), which is calculated as"

Revised (L228):

"To quantify the differences between the output from the site and default data, while also accounting for seasonal fluctuations in the impacts of soil and vegetation on simulated variables (Dirmeyer, 2011; Forzieri et al., 2020), we designed a statistical indicator called the percentage of mean difference (MD %) (Eq. 1). The indicator is calculated as”

Comment 32 (L257): *I don't see superscript "e" in the table?*

Response 32: Thank you for your question. The "e" in the "LAI_default" column for the "US-KS2" row specifies the particular year of the maximum LAI.

Comment 33 (Figure2): *The IGBP type was provided in PLUMBER2, would be interesting to know how different the PFTs provided here are? Much of the PF T information in PLUMBER2 came from site-specific data provided on Fluxnet and regional network websites*

Response 33: Thank you for your question. In this study, the PFT data is sourced from site-related literature, regional networks, and FLUXNET BADM files. We applied certain approximations and processing to the original vegetation cover data, categorizing it according to the 16 PFTs classification to facilitate its use in land surface models. Additionally, these data provide reference sources to allow users to access the original data.

Comment 34 (L285): *This is why it would have been useful to include alternative LAI products and select the most suitable one at each site (PLUMBER2 attempted this but this could no doubt be improved). Only relying on one dataset is arguably not an improvement given the discrepancies*

Response 34: Thank you for your comment. Undoubtedly, providing more LAI products would help readers understand its uncertainties. In our study, we used site data to quantify the uncertainty of remotely sensed LAI (Response 13). Please refer to Response 2 for specific treatment.

Comment 35 (L292): *"provides" might be better*

Response 35: Thank you for your correction and suggestion. We have rephrased this sentence to make it clearer. The comparison before and after modification is as follows:

Origin (L292):

“For the maximum LAI, the file furnishes the range of years for maximum LAI, and the maximum for a specific year.”

Revised (L292):

“For the maximum LAI, the file provides both the year range over which the maximum LAI was observed and the specific maximum value for a given year”

Comment 36 (L355): *Very much agree with this statement. Would be great for this paper to call for the provision of these data in flux data releases*

Response 36: We fully agree with you. We have reformulated this sentence. The comparison before and after modification is as follows:

Origin (L355):

"In land surface community, flux tower attribute data is currently not given enough attention."

Revised (L355):

"In land surface research community, flux tower attribute data is currently not given enough attention. However, the site attribute data is almost as important as the flux tower observations themselves. We recommend that future flux tower datasets, such as the successors of FLUXNET2015, provide standardized site attributes."

Comment 37 (L356): *This is with the caveat that not all sites had site-observed values for the attributes provided?*

Response 37: Thank you for your suggestions. We acknowledge this limitation and have clarified it in the manuscript. The comparison before and after modification is as follows:

Origin (L355):

"Here, we have acquired 90 sites with dependable quality by comprehensive selection, and provided data on vegetation, soil, and topography attributes observed at the site."

Revised (L355):

"In this study, we have acquired 90 sites with high quality by a comprehensive selection process, and provided as many site-observed data as possible on vegetation, soil, and topography attributes."

Comment 38 (L362): *grammar*

Response 38: Thank you for your correction. We have revised it. The comparison before and after modification is as follows:

Origin (L362):

"These updates will therefore help the model's evolution. To collect more site-observed attribute data, while taking into account the diversity described within the same attribute data, particularly the percentage of vegetation cover. We made a few approximations and assumptions in the data collection procedure."

Revised (L362):

"Therefore, these updates will help the model's evolution. To collect more site-observed attribute data, while considering the diversity described within the same attribute data, particularly the percentage of vegetation cover, we made a few approximations and assumptions in the data collection procedure."

Comment 39 (L364): *please provide examples here of what you mean*

Response 39: Thank you for your suggestions. We have revised it.

Origin (L364):

"we made a few approximations and assumptions in the data collection procedure."

Revised (L364):

"we made a few approximations and assumptions in the data collection procedure, such as using approximation substitution and site pictures to assist in judgment."

Comment 40 (L372-379): *this section could be clearer*

Response 40: Thank you for your comment. We appreciate your suggestion to clarify this section. We have revised the text to improve clarity.

Considering your and other reviewers' comments on the discussion of LAI variations, we believe the modeling assessment of attribute data has primarily focused on the magnitude of the impact of attribute data, rather than on sensitivity analyses. We recognize that this passage may cause some misunderstanding. Therefore, after careful consideration, we removed the argument from the manuscript.

The comparison before and after modification is as follows:

Delete (L376): "Notably, unit LAI variations elicit more substantial fluctuations in fluxes at lower LAI values (usually less than 2 m^2/m^2), according to Launiainen et al. (2016). In light of that, all of the sites we chose have LAI values greater than 2 m^2/m^2, except US-GLE, the impact of LAI obtained here are relatively minor."

Origin (L371):

"According to the results, which are in line with earlier research (Dai et al., 2019a), vegetation cover appreciably affects each of the eight variables examined. And among the four attributes, net radiation was the most affected by vegetation cover (Fig. 5). This is due to the cover of plants being the most noticeable surface feature, directly changing surface energy absorption. The net radiation simulation was enhanced using the site PCT_PFT, but the latent and sensible heat did not perform as well. This may be related to the model's previous development and evaluation, which was mostly centered on the IGBP classifications (Dai et al., 2019b; Zhang et al., 2017; Zhu et al., 2017)."

Revised (L371):

"The results are in line with previous research (Dai et al., 2019a), showing that vegetation cover appreciably affects each of the eight variables examined, often being the dominant attribute (Figure 5). This is due to the cover of plants being the most noticeable surface feature, directly altering surface energy absorption. The net radiation simulation was improved using the site PCT_PFT, but the performance of latent and sensible heat simulations was suboptimal. This may be related to uncertainties in the model itself as well as other input data. Such as the vegetation biophysical parameters, soil thermal and hydraulic conductivities, etc. (Dai et al., 2019b; Zhang et al., 2017; Zhu et al., 2017)."

Comment 41 (392): *what do you mean by "the full realization of differences in soil infiltration capacity "?*

Response 41: Thank you for your question. We appreciate the opportunity to clarify this point. By "the full realization of differences in soil infiltration capacity," we mean that during periods of high precipitation intensity, the distinct infiltration capacities of different soil textures become more evident and impactful. In other words, soils with different textures exhibit varying abilities to absorb and transmit water, which becomes particularly pronounced under heavy rainfall conditions. We have revised the manuscript to make this clearer. The comparison before and after modification is as follows:

Origin (L391):

"This is partly attributed to increased water availability and largely to the full realization of differences in soil infiltration capacity under high-intensity precipitation."

Revised (L391):

"This is partly attributed to increased water availability and largely to the pronounced differences in soil infiltration capacity under high-intensity precipitation cases."

Comment 42 (L399): *I don't follow this? "Nevertheless, the data sources were published works, leading to deficiencies for certain sites "*

Response 42: Thank you for your question. What we intended to convey is that while we combined multiple sources to collect as much site-observed attribute data as possible, our reliance on published works meant that some sites had incomplete data. We have revised the manuscript to make this clearer.

Origin (L399):

"Nevertheless, the data sources were published works, leading to deficiencies for certain sites. And the attribute data we collected focused on fundamental soil and vegetation information."

Revised (L399):

"Nevertheless, the data sources we collected were primarily from published works, which led to some missing data for certain sites. And the attribute data focused only on soil and vegetation information."

Comment 43 (L407): *"facilitating perception of the authentic feedback with diverse schemes and processes." What does this mean?*

Response 43: Thank you for your comment. By "facilitating perception of the authentic feedback with diverse schemes and processes," we mean that using site-observed attribute data allowed us to better understand the true effects of different schemes and processes. We have revised the manuscript to make this clearer.

Origin (L406):

“Working with site-observed attribute data enabled us to narrow down factors contributing to model uncertainties, facilitating perception of the authentic feedback with diverse schemes and processes.”

Revised (L406):

“Working with site-observed attribute data enabled us to narrow down factors contributing to model uncertainties, thereby enhancing our understanding of the true effects of diverse schemes and processes.”

Comment 44 (L441): *This would be a great place to call for attribute data to be routinely released as part of flux tower data collections so ancillary data could be accessed more easily and routinely*

Response 44: Thank you for your valuable suggestion. We totally agree with you. We have revised the manuscript to include this important point.

Added (L442):

“We strongly advocate for the routine release of attribute data as part of flux tower data. Making such ancillary data more easily and routinely accessible would greatly increase the value and usability of the data.”

We would like to thank you for your professional review work, constructive comments, and valuable suggestions on our manuscript. We hope the correction made will meet with approval. These comments and suggestions have significantly improved the quality of our manuscript. Once again, thank you very much for the comments and suggestions.

References:

Bonan, G. B., Levis, S., Kergoat, L., and Oleson, K. W.: Landscapes as patches of plant functional types: An integrating concept for climate and ecosystem models: PLANT FUNCTIONAL TYPES AND CLIMATE MODELS, Global Biogeochem. Cycles, 16, 5-1-5–23, https://doi.org/10.1029/2000GB001360, 2002.

Dai, Y., Yuan, H., Xin, Q., Wang, D., Shangguan, W., Zhang, S., Liu, S., and Wei, N.: Different representations of canopy structure—A large source of uncertainty in global land surface modeling, Agricultural and Forest Meteorology, 269–270, 119–135, https://doi.org/10.1016/j.agrformet.2019.02.006, 2019a.

Dai, Y., Wei, N., Yuan, H., Zhang, S., Shangguan, W., Liu, S., Lu, X., and Xin, Y.: Evaluation of Soil Thermal Conductivity Schemes for Use in Land Surface Modeling, J Adv Model Earth Syst, 11, 3454–3473, https://doi.org/10.1029/2019MS001723, 2019b.

Launiainen, S., Katul, G. G., Kolari, P., Lindroth, A., Lohila, A., Aurela, M., Varlagin, A., Grelle, A., and Vesala, T.: Do the energy fluxes and surface conductance of boreal coniferous forests in Europe scale with leaf area?, Glob Change Biol, 22, 4096–4113, https://doi.org/10.1111/gcb.13497, 2016.

Lawrence, P. J. and Chase, T. N.: Representing a new MODIS consistent land surface in the Community Land Model (CLM 3.0), J. Geophys. Res., 112, G01023, https://doi.org/10.1029/2006JG000168, 2007.

Lin, W., Yuan, H., Dong, W., Zhang, S., Liu, S., Wei, N., Lu, X., Wei, Z., Hu, Y., and Dai, Y.: Reprocessed MODIS Version 6.1 Leaf Area Index Dataset and Its Evaluation for Land Surface and Climate Modeling, Remote Sensing, 15, 1780, https://doi.org/10.3390/rs15071780, 2023.

Mauder, M., Foken, T., and Cuxart, J.: Surface-Energy-Balance Closure over Land: A Review, Boundary-Layer Meteorol, 177, 395–426, https://doi.org/10.1007/s10546-020-00529-6, 2020.

Poulter, B., Ciais, P., Hodson, E., Lischke, H., Maignan, F., Plummer, S., and Zimmermann, N. E.: Plant functional type mapping for earth system models, Geosci. Model Dev., 4, 993–1010, https://doi.org/10.5194/gmd-4-993-2011, 2011.

Still, C. J., Berry, J. A., Collatz, G. J., and DeFries, R. S.: Global distribution of C_3 and C_4 vegetation: Carbon cycle implications: C_4 PLANTS AND CARBON CYCLE, Global Biogeochem. Cycles, 17, 6-1-6–14, https://doi.org/10.1029/2001GB001807, 2003.

Ukkola, A. M., Abramowitz, G., and De Kauwe, M. G.: A flux tower dataset tailored for land model evaluation, Earth Syst. Sci. Data, 14, 449–461, https://doi.org/10.5194/essd-14-449-2022, 2022.

Yuan, H., Dai, Y., Xiao, Z., Ji, D., and Shangguan, W.: Reprocessing the MODIS Leaf Area Index products for land surface and climate modelling, Remote Sensing of Environment, 115, 1171–1187, https://doi.org/10.1016/j.rse.2011.01.001, 2011.

Zhang, X., Dai, Y., Cui, H., Dickinson, R. E., Zhu, S., Wei, N., Yan, B., Yuan, H., Shangguan, W., Wang, L., and Fu, W.: Evaluating common land model energy fluxes using FLUXNET data, Adv. Atmos. Sci., 34, 1035–1046, https://doi.org/10.1007/s00376-017-6251-y, 2017.

Zhou, Y., Sühring, M., and Li, X.: Evaluation of energy balance closure adjustment and imbalance prediction methods in the convective boundary layer – A large eddy simulation study, Agricultural and Forest Meteorology, 333, 109382, https://doi.org/10.1016/j.agrformet.2023.109382, 2023.

Zhu, S., Chen, H., Zhang, X., Wei, N., Shangguan, W., Yuan, H., Zhang, S., Wang, L., Zhou, L., and Dai, Y.: Incorporating root hydraulic redistribution and compensatory water uptake in the Common Land Model: Effects on site level and global land modeling, J. Geophys. Res. Atmos., 122, 7308–7322, https://doi.org/10.1002/2016JD025744, 2017.