## Reply to Referee #2' s comments

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

*This paper describes a dataset based on flux-tower measurements obtained from network databases, which underwent additional quality control and were combined with ancillary data characterizing the sites. The dataset was created to make flux-tower measurements including site characteristics available to the land surface modelling community, enabling site-level simulations with site-specific soil and vegetation information, where available. The additional quality control reduced the number of available sites and resulted in discontinuous time series at least at some sites. The paper shows that land surface model (LSM) simulations with soil and vegetation characteristics obtained from global gridded datasets instead of site-specific data can lead to large differences in simulated pools and fluxes.*

*I believe that a dataset including both flux-tower observations as well as site attributes required to run and evaluate LSMs is of interest to the community and useful for model development. The paper is generally well organized and written. There are, however, several sentences, which are not completely clear and should be rephrased. Generally, the paper should be checked and corrected for language issues. I have mentioned some, but not all, of these in the specific comments. I suggest that the below comments should be addressed before publication.*

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

All comments are addressed on a point-by-point basis below. The comments are laid out below 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:*** *It should be made clearer what exactly the quality control entailed and whether all variables were removed from the dataset, when one of the variables was gap-filled or had lower quality data, or if just that particular variable was removed. It is not completely clear to me whether both the atmospheric forcing variables and the flux measurements used to evaluate LSMs have discontinuous timeseries in the dataset. If the forcing variables are discontinuous, the authors should make it clearer how this is handled in LSMs and how the data are still useful for LSMs.*

**Response1:** Thank you for your careful evaluation of this manuscript. We fully agree with your opinion. We have provided a more detailed description of the variables excluded by quality control. Additionally, during the screening process, we excluded all variables when one of the variables was gap-filled or had lower quality data, because the selected variables were basic, and users can still easily obtain the full variables and time series through PLUMBER2. This is a brief response, please refer to Response 16 for specific details.

Discontinuous meteorological data are indeed difficult to apply to LSMs. Therefore, we simulated all years in the PLUMBER2 dataset, but subsequent analyses are conducted exclusively for the years we have chosen. Please refer to Response 18 for specific details.

***Comment 2:*** *Regarding the soil attributes that were included for the sites, I'd be interested why the authors do not mention soil depth. I'm aware that soil depths measurements are generally not available for the sites, but it is an important variable in many LSMs. Even if it is obtained from global gridded datasets, it could still be useful to include in this dataset. Another variable, which was not included, is the measurement height of air temperature. As this is required in several LSMs and is not always the same height as the measurement height of wind speed, I think it would be useful to include the air temperature measurement height as well or explain why it was not included.*

**Response 2:** We totally agree with your suggestion. We have added soil depth as well as the measurement heights of air temperature and humidity to the attribute dataset. Please see Responses 7 and 12 for the processing of soil depth, and Response 13 for the processing of measurement heights of air temperature and humidity.

***Comment 3:*** *Some of the Tables and Figures could be improved by organizing sites in the same order for the different variables that are shown or to show the selected variables for all the sites. For example, Table 2 and Figure 7 could be made clearer.*

**Response 3:** Thank you for your suggestions. We apologize for the ambiguity. We have reorganized Table 2 by adding the latitude and longitude for the sites and lining up all sites in a single column. The site order is arranged according to the first letter. Please see Response 22 for changes to Table 2.

Figure 7 is intended to illustrate that the impact of attributes is substantially associated with precipitation. We intentionally chose two typical sites for each attribute and formed a contrasting effect to illustrate the important role of precipitation. Therefore, only 8 sites are ultimately shown. We have added this information to the description of Figure 7. Please refer to Response 31 for specific details.

***Comment 4 (L15):*** *Be more specific what you mean with "external disturbances"? Aren't all disturbances external?*

**Response 4:** Thank you for your question. I'm sorry I didn't make it clear "external disturbances". It includes irrigation, deforestation, and water body disturbance (details in L132). The specific disturbance events for the 10 disturbed sites are shown in Table S3. We have clarified this according to your suggestion.

**Origin (L15):**

"including the proportion of gap-filled data, external disturbances, and energy balance closure (EBC),"

**Revised (L15):**

"including the proportion of gap-filled data, energy balance closure (EBC), and external disturbances such as irrigation and deforestation,"

***Comment 5 (L51):*** *It should be "at some sites".*

**Response 5:** Thank you for your correction. We have revised it.

**Origin (L51):**

"in some sites"

**Revised (L51):**

"at some sites"

***Comment 6 (L55):*** *For site-level simulations, it isn't always the case that gridded data products are used to obtain soil textures, etc., if site-specific information is available in the literature.*

**Response 6:** Thank you for your correction. It is true, as you say, that the attribute data used is not always globally gridded data products. 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 obtains these attribute data"

***Comment 7 (L76):*** *Why are LAI and canopy height included in the four most important attributes, even though they aren't required as inputs for many LSMs? Soil depth, however, is not mentioned, which can strongly impact model outputs and is required my many LSMs as well.*

**Response 7:** Thank you for your question. Yes, if the Dynamic Global Vegetation Model (DGVM) is not activated, LAI and canopy height are not required for LSMs. This approach is mainly suitable for long-term climate simulations. In such cases, LSMs use the canopy structural parameters from DGVM's outputs. However, in a relatively short-term simulations (i.e., weather or seasonal scale) or historical simulations (i.e., current climate 2000-2020), the DGVM is typically turned off and prescribed LAI and tree height values are used (Forzieri et al., 2020; Zeng et al., 2017). These values are generally derived from remote sensing 'observations' or in-situ measurements. This is the approach employed in our study. An important reason for this approach is that LAI and canopy height are critical vegetation structure data. In particular, LAI affects processes such as radiative transfer and surface flux exchanges. Canopy height directly determines the zero-plane displacement height and the roughness length, consequently influencing the intensity of land-atmosphere flux exchange. The LAI or canopy height simulated by DGVMs generally shows larger uncertainties compared to remote sensing or in-situ observations. That's why we collected the LAI, canopy height values in this study.

Thanks for the reminder. Soil depth is indeed an indispensable variable in LSMs. Therefore, we have added the site soil depth data to the attribute dataset. The dataset is available at https://doi.org/10.5281/zenodo.12596218. We have also updated the graphs and related text describing the attribute data.

**Origin (L187):**

**Soil bulk density and organic carbon concentration**

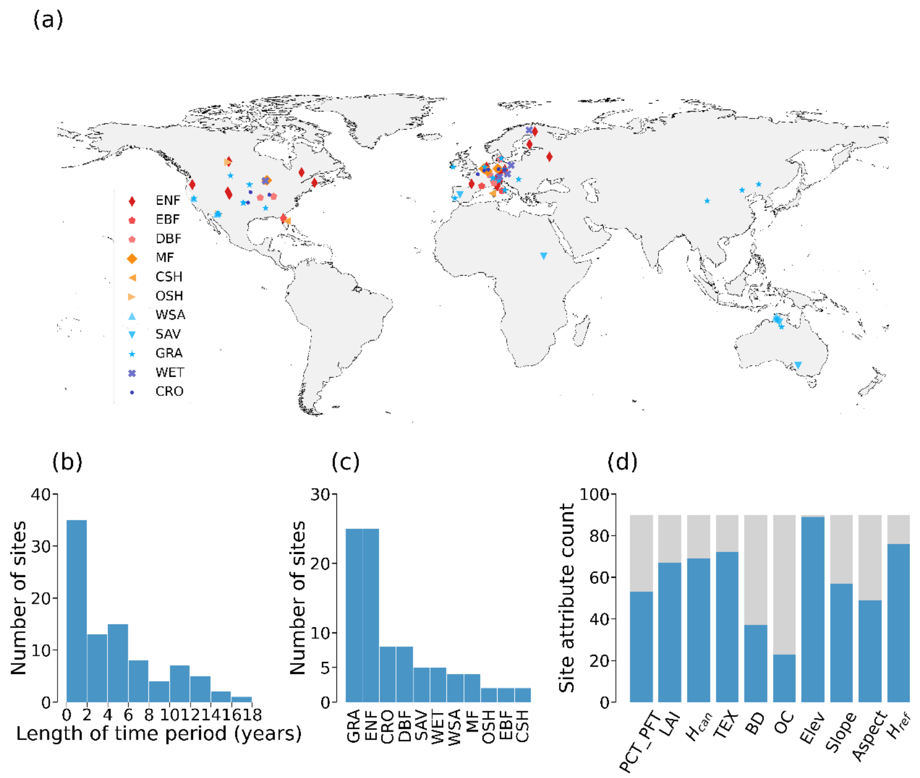
Soil bulk density and organic carbon concentration data are sourced from site descriptions in literature, regional networks, and AmeriFlux BADM file. Specifically, soil bulk density data were collected at 37 sites, and soil organic carbon concentration at 23 sites. At 32 and 22 sites, respectively, the observation depth was given. Despite the scarcity of site-observed data for these two soil attributes, we have included them in the final dataset. For site-specific studies, they can provide useful references for researchers.

**Revised (L197):**

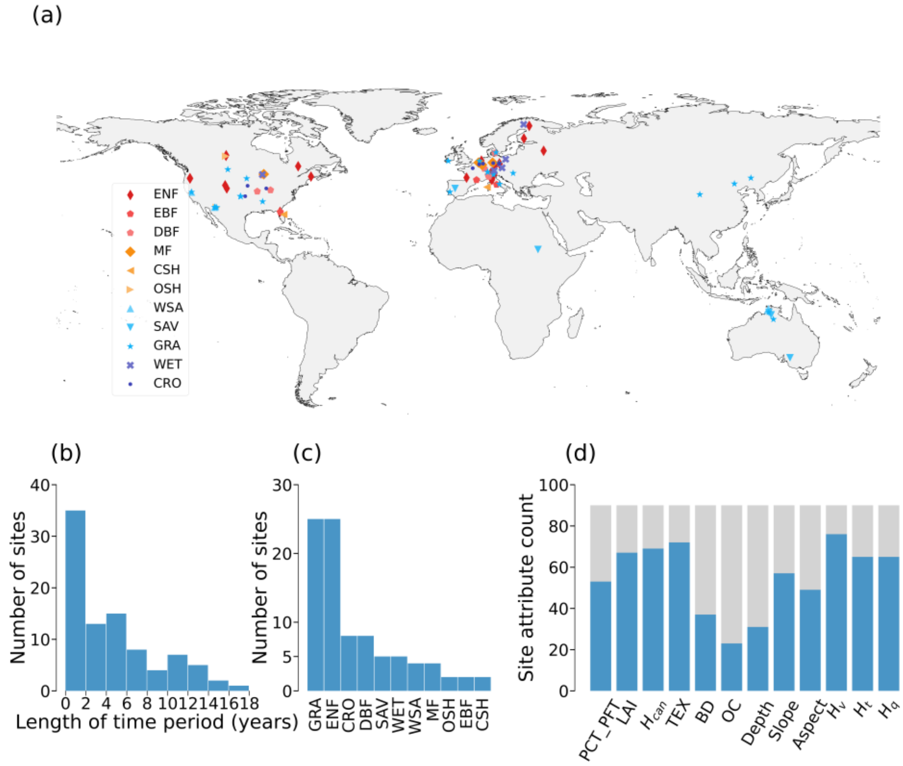
**Soil bulk density, organic carbon concentration, and depth**

Soil bulk density, organic carbon concentration, and depth data are sourced from site descriptions in literature, regional networks, and AmeriFlux BADM file. Specifically, soil bulk density was collected at 37 sites, soil organic carbon concentration at 23 sites, and soil depth at 31 sites. The observation depth was provided for soil bulk density at 32 sites and for organic carbon concentration at 22 sites. Despite the scarcity of site-observed data for the three soil attributes, we have included them in the final dataset. For site-specific studies, they can provide useful references for researchers.

**Origin (Figure 2):**



**Revised (Figure 2):**




**Origin (Figur 2 caption):**

"(d) Number of collected site-observed attribute data for PCT_PFT, maximum LAI (LAI), mean canopy height ($H_{can}$), soil texture (TEX), bulk density (BD) and organic carbon concentration (OC), elevation (Elev), slope, aspect, and wind reference measurement height (H_ref)."

**Revised (Figur 2 caption):**

"(d) Number of collected site-observed attribute data for PCT_PFT, maximum LAI (LAI), mean canopy height ($H_{can}$), soil texture (TEX), bulk density (BD), organic carbon concentration (OC), and soil depth (Depth), slope, aspect, and reference measurement height (Wind: $H_v$; Air temperature: $H_t$; Humidity: $H_q$)."

**Origin (Table 3):**

| Variable (Dimension) | Long name | Unit | Description |
|---|---|---|---|
| PCT_PFT (pft=16) | Percent plant functional types cover | % | Source[a]; |
| LAI_Max | Maximum leaf area index | $m^2/m^2$ | Source; year_range[b]; LAI_Max_year[c] |
| Canopy_height | Canopy height | m | Source; |
| Soil_TEX (particle_size=3, soil_layer=4) | Soil texture(sand/silt/clay) | % | Source; layer_n_depth[d] |
| Soil_BD (soil_layer=4) | Soil bulk density | g $cm^{-3}$ | Source; layer_n_depth[d] |
| Soil_OC (soil_layer=4) | Soil organic carbon concentration | % | Source; layer_n_depth[d] |
| Elevation | Site elevation | m | Source; |
| Slope | Site slope | - | Source; |
| Aspect | Site aspect | - | Source; |
| Reference_height | Measurement height of wind speed or flux | m | Source; Measurement variable (Wind or Flux) |
| year_qc (year=21) | Selected year of high-quality data | - | - |

**Revised (Table 3):**

| Variable (Dimension) | Long name | Unit | Description |
|---|---|---|---|
| PCT_PFT (pft=16) | Percent plant functional types cover | % | Source[a]; |
| LAI_Max | Maximum leaf area index | $m^2/m^2$ | Source; year_range[b]; LAI_Max_year[c] |
| Canopy_height | Canopy height | m | Source; |
| Soil_TEX (particle_size=3, soil_layer=4) | Soil texture(sand/silt/clay) | % | Source; layer_n_depth[d] |
| Soil_depth | Soil depth | cm | Source; |
| Soil_BD (soil_layer=4) | Soil bulk density | g $cm^{-3}$ | Source; layer_n_depth[d] |
| Soil_OC (soil_layer=4) | Soil organic carbon concentration | % | Source; layer_n_depth[d] |
| Slope | Site slope | - | Source; |
| Aspect | Site aspect | - | Source; |
| Reference_height_v | Measurement height of wind speed or flux | m | Source; Measurement variable (Wind or Flux) |
| Reference_height_t | Measurement height of air temperature or flux | | Source; Measurement variable (Wind or Flux) |
| Reference_height_q | Measurement height of air humidity or flux | | Source; Measurement variable (Wind or Flux) |
| year_qc (year=21) | Selected year of high-quality data | - | - |

***Comment 8 (L85):** What are the "7 site-related articles" and why do you mention the number? It doesn't seem like you use site-specific publications for all the sites, so what is special about these 7?*

**Response 8:** Thank you for your question. These 7 site-related articles contain information on the proportions of C3/C4 grass and are therefore used for PFTs classification (including sites AU-How, PT-Mi2, SD-Dem, US-Aud, US-Fpe, US-Var, US-Wkg). We apologize for not being clearly explained for the 7 site-related articles. We have added new footnotes to Table S1 to clarify these articles and their corresponding sites.

**Origin (L85):**

"*7 site-related articles*"

**Revised (L85):**

"7 site-related articles for C3/C4 classification"

**Add (Table S1):**

"[f] Sites using literature descriptions for C3/C4 classification"

***Comment 9 (L90):** Better than what?*

**Response 9:** Thank you for your question. Here it means better than MODIS LAI. To provide a clearer introduction to the reprocessed MODIS LAI, we have reorganized language. The comparison before and after modification is as follows:

**Origin (91):**

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

**Revised (91):**

"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 10 (L93):*** *What exactly do you mean with "LAI complements"? Are these site measurements gap-filled with MODIS LAI?*

**Response 10:** Thank you for your question. We apologize for the ambiguity. "LAI complements" indicates site measurements gap-filled with MODIS LAI. we have changed the wording to express it more clearly.

**Origin (93):**

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

**Revised (93):**

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

***Comment 11 (L96):*** *It should be "use" instead of "using". Otherwise, the sentence is incomplete.*

**Response 11:** Thank you for your correction. We have revised it.

**Origin (96):**

"Complements of soil texture using"

**Revised (96):**

"Filling of soil texture uses"

***Comment 12 (L105):*** *Why don't the soil attributes include soil depth? That is used in many LSMs as well and can have strong impacts on soil moisture and temperatures.*

**Response 12:** Thank you for your suggestion. We agree that soil depth is indeed an important variable in LSMs. However, many LSMs currently treat soil depth in a simplistic manner, setting it to a constant value (e.g., CABLE, CoLM, Noah-MP, etc.) on a global scale. Therefore, we did not consider soil depth in the initial attribute dataset.

Considering that soil depth has strong impacts on soil moisture and temperatures, we have added the site soil depth values to the attribute dataset. The updated dataset is available at https://doi.org/10.5281/zenodo.12596218.

***Comment 13 (L108):*** *What do you mean with "revised by wind speed measurement height"? Also, why only wind speed? The measurement height of air temperature is required by many models as well and isn't always the same height as the wind speed measurement height.*

**Response 13:** Thank you for your question. There is no specific observed variable for the reference measurement height of existing flux tower dataset. Given that wind speed varies most at different heights, we use the wind speed measurement height as the reference measurement height. That is "revised by wind speed measurement height".

Indeed, as you say, the measurement height of air temperature is required by many models as well and isn't always the same height as the wind speed measurement height. We fully agree with you. So, we have added the reference measurement heights for air temperature and humidity to the attribute dataset as well. Thank you very much for your suggestion. The updated dataset is available at https://doi.org/10.5281/zenodo.12596218.

We have also updated the graphs and related text describing the attribute data in the article.

**Origin (106):**

"the reference measurement height (for emulating the lowest layer of the atmospheric model to which the LSM would be coupled) was revised by wind speed measurement height if possible."

**Revised (106):**

"We obtained the reference measurement height (for emulating the lowest layer of the atmospheric model to which the LSM would be coupled) of wind speed, air temperature, and air humidity."

**Origin (200):**

"From these sources, we look for the height of wind speed measurement or the height of instrument used to wind speed measurements (such as the wind cup)."

**Revised (200):**

"From these sources. we look for the height of wind speed/air temperature/air humidity measurement or the height of the instrument used for measurements (such as the wind cup and temperature and humidity sensor)."

**Origin (203):**

"As a result, wind observation heights are available for a total of 76 sites."

**Revised (203):**

"As a result, wind observation heights are available for a total of 76 sites, and 65 sites are available for air temperature and humidity observation heights."

***Comment 14 (L109):*** *"breakdown to" should be "broken down into"*

**Response 14:** Thank you for your correction. We have revised it.

**Origin (L109):**

"the FVC was further breakdown to different PFTs"

**Revised (L109):**

"the FVC was further broken down into different PFTs"

***Comment 15 (Table1):*** *Why is the MODIS LAI dataset included in the table twice?*

**Response 15:** Thank you for your question. This is because the global LAI product needs to be used twice during attribute dataset generation. The first time is for C3/C4 classification (data usage: PFT information), which is described in L144. The second time is to fill in the LAI for missing measurements at the site. Therefore, the MODIS LAI dataset is included twice in the table.

***Comment 16 (L123):*** *Did you exclude those years for both the fluxes and meteorology? Why did you not just remove the low-quality fluxes, but kept the meteorology and high-quality flux data for those time periods? To evaluate the model simulations, you do not necessarily need all flux data. Only the meteorological forcings have to be complete and they do not have to be of low quality, when some of the flux measurements are.*

**Response 16:** Thank you for your question. We excluded those years for both the fluxes and meteorology. We agree with you that more meteorological and flux observations could have been retained.

We excluded all flux data for two main reasons: (1) latent and sensible heat are the most important variables in land-atmosphere exchange and are the first variables to be assessed in land-atmosphere exchange. So, when the quality of latent and sensible heat is poor, we exclude all fluxes. (2) The period of poorer quality of observations for latent and sensible heat usually implies poorer quality of turbulent exchanges (e.g., carbon exchanges including GPP and respiration; friction velocities).

Despite these, there are still some model results that can be evaluated (e.g., the net and upward shortwave radiation). Therefore, we provide a more detailed description of each excluded year. Label whether the exclusion is due to the poor quality of flux, meteorology, or both. We will add this information to Tables S2 and S3 in the manuscript submission after the end of the Discussions. This allows the user to get more detailed data quality information and to choose simulation years and assessment variables according to individual needs. In addition, it should be noted that the attribute dataset only provides the results of the quality screening, and the user can still easily obtain the full variables and time series through PLUMBER2.

As you mentioned, the flux data used for evaluation does not need to be continuous. We fully agree that this approach maximizes the utilization of available data. Here, we adopted a stricter criterion by filtering the flux data annually, which enhances user convenience. Many studies also apply annual criteria for data selection. Finally, if users require flux observations for specific periods, they can easily obtain the full time series with corresponding QC flags from PLUMBER2.

***Comment 17 (L132):*** *What do you mean with "impacted by a sizable body of water"? Was the site flooded or did a lake or so develop at the site?*

**Response 17:** Thank you for your question. Here, "impacted by a sizable body of water" means "This site is unusual: it is situated on a low-lying narrow spit of land between a small lake and the Mediterranean Sea and is likely heavily influenced by horizontal advection" (Haughton et al., 2016). I'm sorry for the ambiguity. We have added reference sources here.

**Origin (L132):**

"such as irrigation, deforestation, and one site impacted by a sizable body of water"

**Revised (L132):**

"such as irrigation, deforestation, and one site impacted by a large body of water nearby (details in Table S3)"

***Comment 18 (L132):*** *"we preserved non-consecutive years that met the criteria" - Does this apply to both the meteorology as well as fluxes? As the meteorology is needed to force LSMs, using discontinuous years of meteorological data seems like it would not be very useful for LSMs and could cause crashes or strange behaviour in models, if the meteorology suddenly shifts with jumps in time. The end of one year could be much colder/warmer or wetter/drier than the beginning of the next available year, which would likely cause the model state to be out of phase with the actual meteorological conditions. Why did you decide on this approach? Also, why not include high-quality gap-filled data at least for the meteorological forcings. For the fluxes, which are only used to evaluate the models, it seems reasonable to only keep measured values, but that does not mean that the meteorology has to be discarded as well.*

**Response 18:** Thank you for your question. "we preserved non-consecutive years that met the criteria"——this applies to both the meteorology as well as fluxes.

Discontinuous meteorological data are indeed difficult to apply to LSMs. Therefore, we simulated all years in the PLUMBER2 dataset (details in L222). The meteorological data for these years are relatively reliable, except that the specific humidity at some of the sites was not thoroughly quality screened (details in L118).

High quality gap-filled data are necessary. Therefore, our quality screening considered data with high quality gap-filled data. For fluxes, data with QC = 1 were considered (details in L123). For meteorological variables, we followed PLUMBER2 and kept a smaller proportion of gap-filled data (details in L126). This is because specific humidity is one of the five variables (including incoming shortwave radiation, precipitation, air temperature, air humidity, and wind speed) that have strong impacts on LSMs (Ukkola et al., 2022).

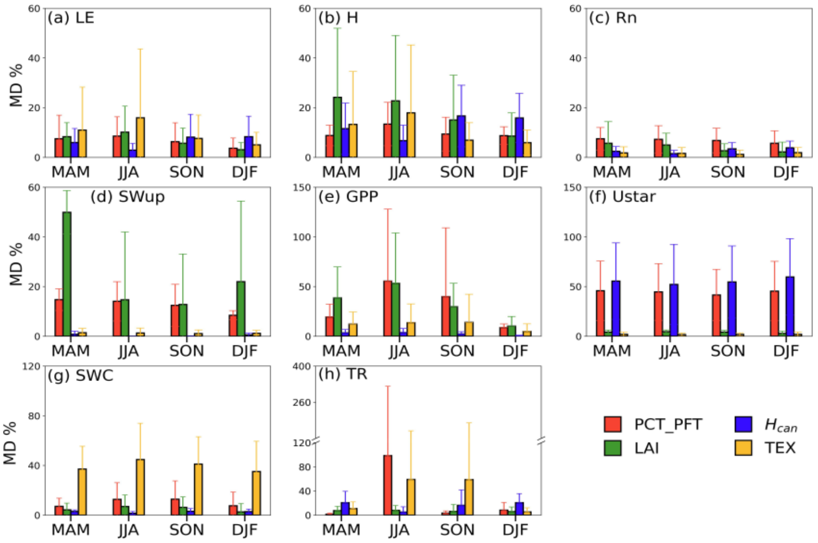
The attribute dataset provides the results of the quality screening. As described in Response 16, we provide more detail on the excluded years, and the user still has access to all of the variables with the time series (including the meteorological variables) according to their needs.

***Comment 19 (L224):*** *Why only the first year and not all available years at the sites? One year could be* *an unusual/extreme year and not representative of the usual site conditions.*

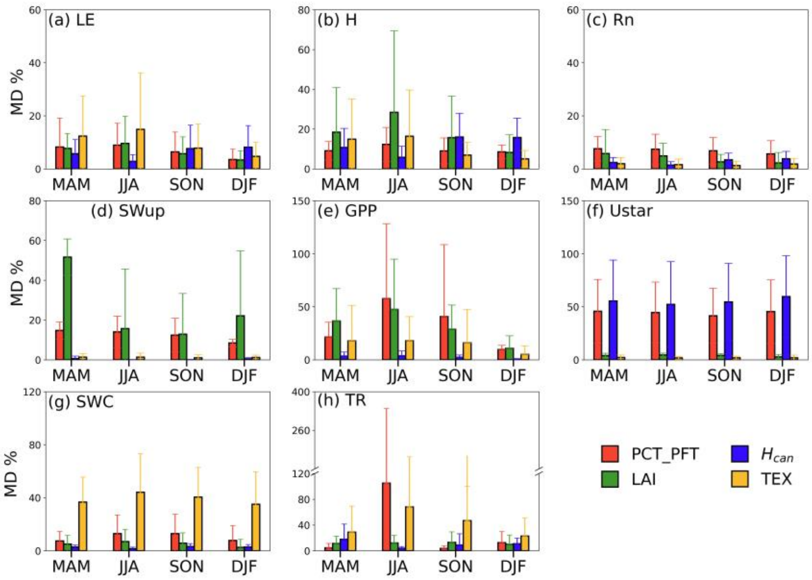
**Response 19:** Thank you for your suggestion. It's true that using only one year of data for SPIN-UP is not quite right. Therefore, we have changed the SPIN-UP approach. The new scheme loops the atmospheric forcing data for each site's observation period until it reaches 50 years.

We redrew the pictures associated with the model results (including Figure 4, Figure 5, Figure 6, and Figure 7). Overall, these figures don't change much. And the relevant MD% values in this paper are modified. The comparison before and after modification is as follows:

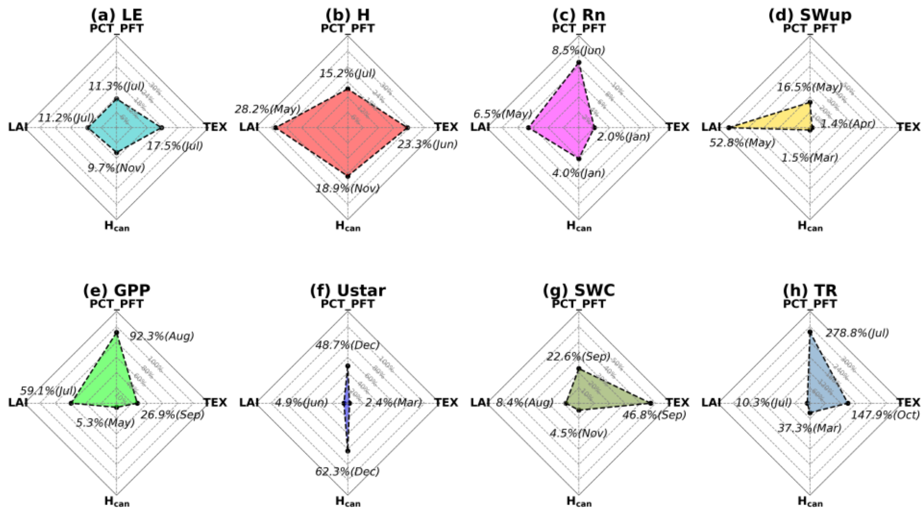
**Origin (Figure 4):**



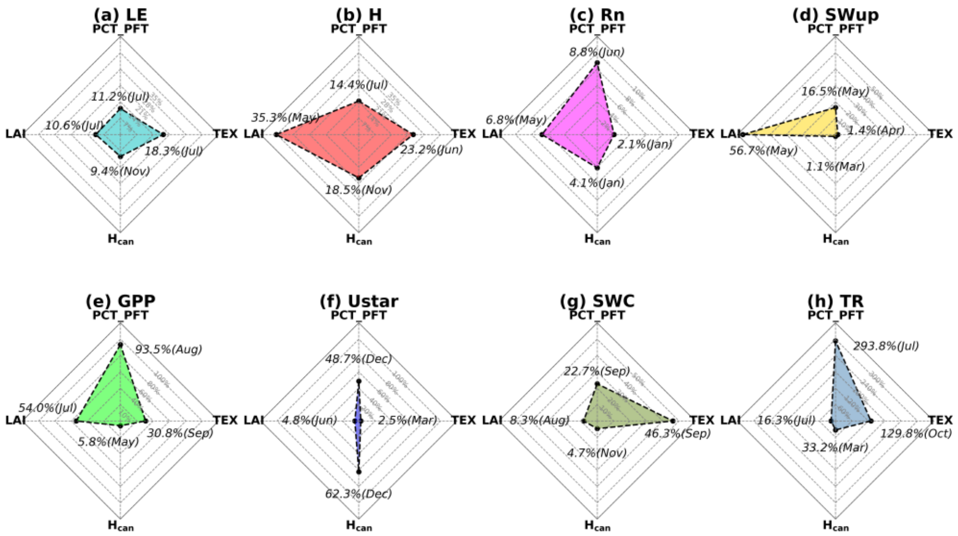

**Revised (Figure 4):**



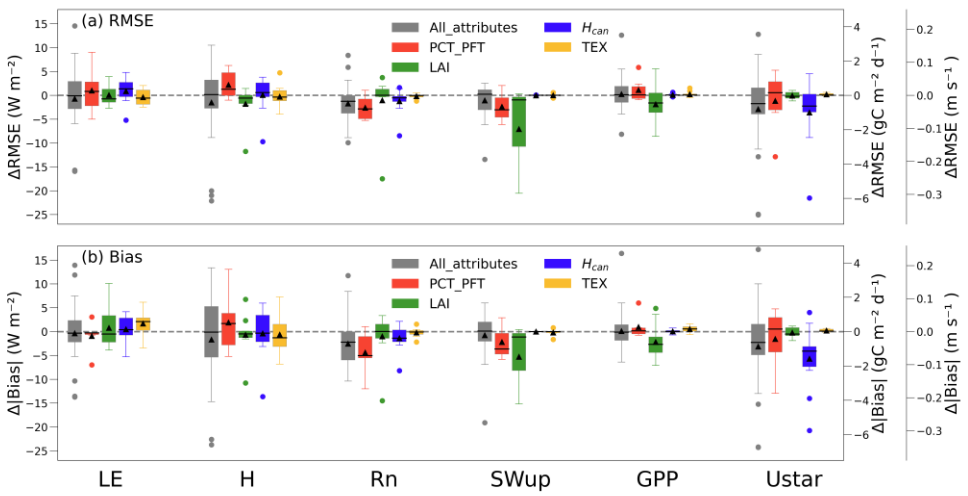

**Origin (Figure 5):**



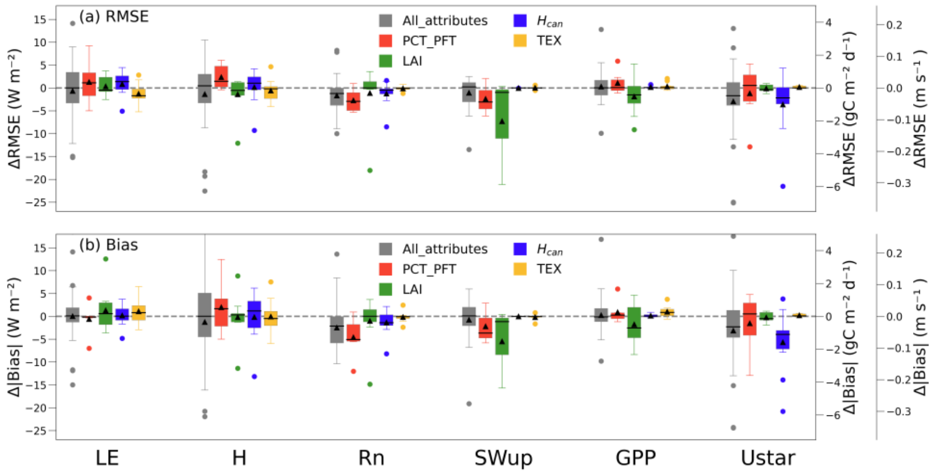

## Revised (Figure 5):



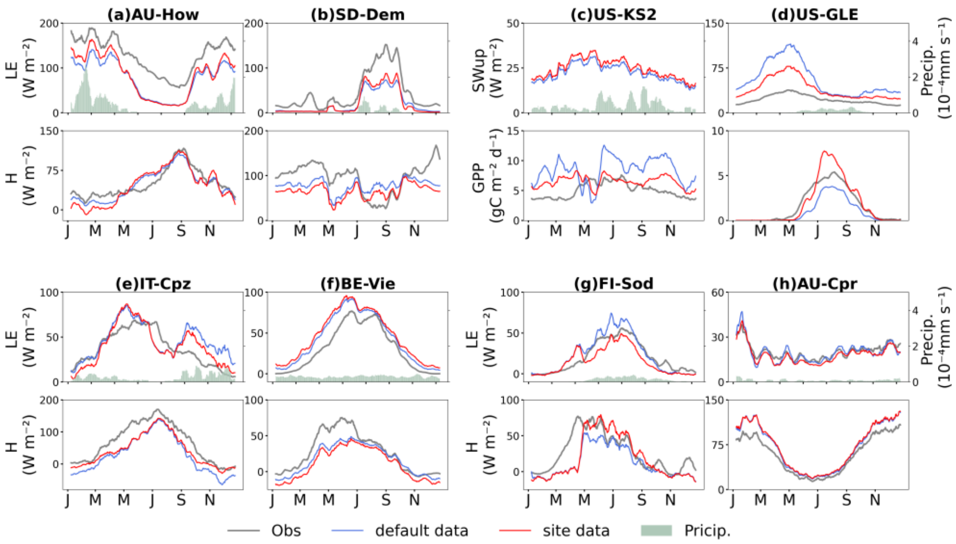

## Origin (Figure 6):



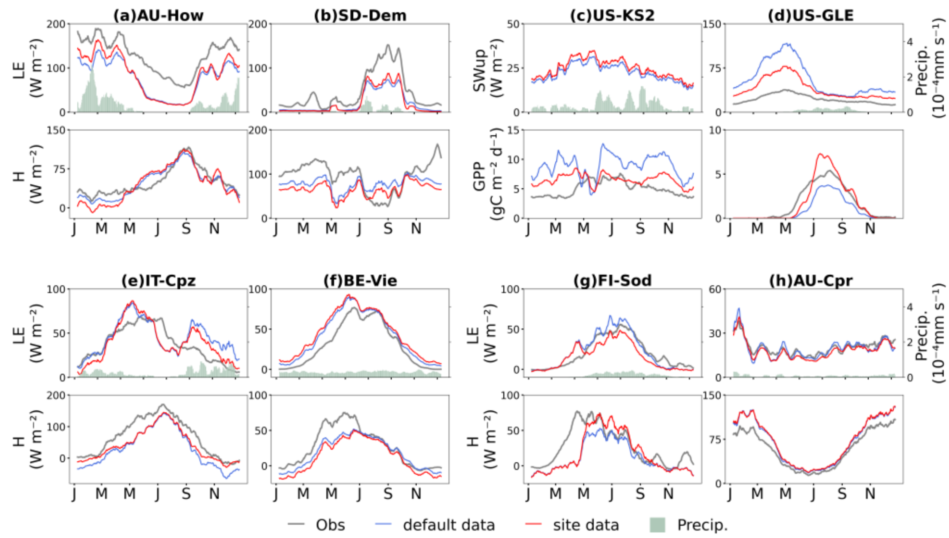

## Revised (Figure 6):




## Origin (Figure 7):




## Revised (Figure 7):



***Comment 20 (L225):*** *Why only do such a short spin-up, if GPP is evaluated as well? Are the vegetation and soil C pools prescribed and not dynamic?*

**Response 20:** Thank you for your question. We apologize for the ambiguity. In our experiments, There is no C pools simulation here, the dynamic vegetation module is turned off and the time-variant LAI and stem area index (SAI) values are prescribed from the reprocessed MODIS LAI data. Therefore, we performed a relatively short spin-up.

Based on your comments, we have added a description of the model.

**Add (L208):**

"CoLM202X incorporates processes related to biogeophysics, biogeochemistry, ecological dynamics and human activities, and also offers optional processes and schemes which can be customized by the user. In our experiments, vegetation is modeled using a set of time-invariant parameters (optical properties: leaf optical properties; morphological properties: canopy height, vegetation root depth and profile, leaf size and angle distributions; and physiological properties). The dynamic vegetation module is turned off and the time-variant LAI and stem area index (SAI) values are prescribed from the reprocessed MODIS LAI data (Lin et al., 2023; Yuan et al., 2011). The two-big-leaf model (Dai et al., 2004) is employed to calculate processes such as radiative transfer (Yuan et al., 2017), photosynthesis (Collatz et al., 1992; Farquhar et al., 1980), and stomatal conductance (Ball et al., 1987). Surface turbulent exchange is simulated using similarity theory (Brutsaert, 1982; Zeng and Dickinson, 1998). Total evapotranspiration includes evaporation from stems, leaves, and the ground, as well as vegetation transpiration. Surface and subsurface runoff consider factors such as terrain, groundwater level, precipitation, and infiltration rate. Additionally, the model accounts for processes including precipitation phase and intensity, canopy interception, vertical movement of water in snow and soil, and snow compaction (Dai et al., 2003)."

***Comment 21 (L228):*** *What do you mean here? It seems like the sentence is incomplete. Is the next sentence supposed to be part of this sentence?*

**Response 21:** Thank you for your correction. The next sentence is part of this sentence. We have revised it according to your suggestion.

**Origin (229):**

"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 (229):**

"on climate-related 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 22 (Table 2):*** *Why do you show the different attributes for different sites? Wouldn't it make more sense to select the same sites and same order of sites in the table for all attributes? Then, you also only need the site column once and it's less confusing. Regarding soil texture: are the values averages* *over different depth or values for the top layer/near-surface?*

**Response 22:** Thanks for your question. "Show the different attributes for different sites" is because different sites were selected to show simulation differences for different attributes (see L216 for details on site selection methods). However, we have reorganized Table 2 by adding the latitude and longitude for the sites and lining up all sites in a single column. The site order is arranged according to the first letter.

For soil texture, these values are for the top layer/near-surface. We have added this information to the Table 2 (footnote 'c').

**Origin (Table 2):**

| **Site** | **LAI_default[a] ($m^2/m^2$)** | **LAI_site[b] ($m^2/m^2$)** | **Site** | **TEX_default[c]** | **TEX_site[b]** |
|---|---|---|---|---|---|
| US-KS2 | 6.6 (2005[e]) | 2.7 (2005) | IT-Cpz | 33/45/22 | 87/8/5 |
| DK-Lva | 3.1 (2004) | 6.9 | DE-Gri | 52/29/20 | 10/81/9 |
| DE-Bay | 3.6 | 6.5 | FI-Sod | 52/25/20 | 92/5/3 |
| US-Goo | 4.5 | 2.0 | ES-LMa | 49/24/24 | 80/11/9 |
| DE-Seh | 3.2 (2009) | 5.9 (2009) | AU-Cpr | 64/18/18 | 94/4/2 |
| US-GLE | 1.5 | 3.8 | SD-Dem | 67/18/14 | 96/4/0 |
| US-Moz | 6.1 (2006) | 4.0 (2006) | CZ-wet | 39/37/32 | 10/85/5 |
| DE-Gri | 6.5 (2004) | 4.4 (2004) | AU-DaP | 63/18/19 | 92/5/3 |
| IT-Cpz | 5.4 | 3.5 | AU-DaS | 63/12/25 | 92/5/3 |
| US-MMS | 7.0 | 5.2 | IT-SRo | 69/17/15 | 95/4/1 |
| **Site** | **$H_{can}$_default[d] (m)** | **$H_{can}$_site[b] (m)** | **Site** | **IGBP** | **PCT_PFT_site[b]** |
| IT-Cpz | 35 | 14.3 | AU-How | WSA | EBT_Tr/DBS_Te/C4 : 50/25/25 |
| BE-Vie | 17 | 33.7 | ES-LMa | SAV | EBT_Te/C3 : 20/80 |
| AU-Lit | 35 | 20.0 | SD-Dem | SAV | EBT_Tr/C3/C4 : 10/27/63 |
| DE-Hai | 20 | 33.9 | US-SRM | WSA | DBS_Te/C3/C4 : 35/43/22 |
| IT-Ren | 17 | 29.0 | US-Ton | WSA | EBT_Te/C3 : 40/60 |
| DE-Tha | 17 | 28.4 | US-Whs | OSH | Bare/DBS_Te/C3 : 39/51/10 |
| IT-Lav | 17 | 28.0 | | | |
| US-Ton | 20 | 9.9 | | | |
| RU-Fyo | 17 | 26.3 | | | |
| CH-Dav | 17 | 25 | | | |

[a] The maximum LAI at the pixel containing the site provided by Reprocessed MODIS version 6.1 LAI.

[b] Site-observed data collected in this study. [c] Soil texture (sand/silt/clay) at the site location extracted from the GSDE dataset. [d] Canopy height of the dominant vegetation type at the site from the CoLM lookup table. [e] Specific year of maximum LAI.

**Revised (Table 2):**

| **Site_LAI** | **Lat** | **Lon** | **LAI_default[a]($m^2/m^2$)** | **LAI_site[b](m2/m2)** |
|---|---|---|---|---|
| DE-Bay | 54.142 | 11.867 | 3.6 | 6.5 |
| DE-Gri | 50.949 | 13.512 | 6.5 (2004) | 4.4 (2004) |
| DK-Lva | 55.683 | 12.083 | 3.1 (2004) | 6.9 (2004) |
| DE-Seh | 58.871 | 6.449 | 3.2 (2009) | 5.9 (2009) |
| IT-Cpz | 41.706 | 12.376 | 5.4 | 3.5 |
| US-GLE | 41.366 | -106.24 | 1.5 | 3.8 |

| | | | | |
|---|---|---|---|---|
| US-Goo | 34.254 | -89.873 | 4.5 | 2.0 |
| US-KS2 | 28.605 | -80.671 | 6.6 (2005[e]) | 2.7 (2005) |
| US-MMS | 39.323 | -86.413 | 7.0 | 5.2 |
| US-MOz | 38.744 | -92.200 | 6.1 (2006) | 4.0 (2006) |
| **Site_TEX** | **Lat** | **Lon** | **TEX-default[c]** | **TEX_site[b]** |
| AU-Cpr | -34.002 | 140.589 | 64/18/18 | 94/4/2 |
| AU-DaP | -14.063 | 131.318 | 63/18/19 | 92/5/3 |
| AU-DaS | -14.159 | 131.388 | 63/12/25 | 92/5/3 |
| CZ-wet | 49.024 | 14.770 | 39/37/32 | 10/85/5 |
| DE-Gri | 50.949 | 13.512 | 52/29/20 | 10/81/9 (0-23cm) |
| ES-LMa | 39.942 | -5.773 | 49/24/24 | 80/11/9 (0-30cm) |
| FI-Sod | 67.361 | 26.637 | 52/25/20 | 92/5/3 |
| IT-Cpz | 41.706 | 12.376 | 33/45/22 | 87/8/5 (0-10cm) |
| IT-SRo | 43.727 | 10.284 | 69/17/15 | 95/4/1 (10-20cm) |
| SD-Dem | 13.282 | 30.478 | 67/18/14 | 96/4/0 |
| **Site_HTOP** | **Lat** | **Lon** | **$H_{can}$_default[d] (m)** | **$H_{can}$_site[b] (m)** |
| AU-Lit | -13.179 | 130.794 | 35 | 20.0 |
| BE-Vie | 50.305 | 5.998 | 17 | 33.7 |
| CH-Dav | 46.815 | 9.855 | 17 | 25 |
| DE-Hai | 51.079 | 10.453 | 20 | 33.9 |
| DE-Tha | 50.936 | 13.566 | 17 | 28.4 |
| IT-Cpz | 41.706 | 12.376 | 35 | 14.3 |
| IT-Lav | 45.956 | 11.281 | 17 | 28.0 |
| IT-Ren | 46.586 | 11.433 | 17 | 29.0 |
| RU-Fyo | 56.461 | 32.922 | 17 | 26.3 |
| US-Ton | 38.431 | -120.966 | 20 | 9.9 |
| **Site_FVC** | **Lat** | **Lon** | **IGBP** | **PCT_PFT_site[b]** |
| AU-How | -12.495 | 131.149 | WSA | EBT_Tr/DBS_Te/C4 : 50/25/25 |
| ES-LMa | 39.942 | -5.773 | SAV | EBT_Te/C3 : 20/80 |
| SD-Dem | 13.282 | 30.478 | SAV | EBT_Tr/C3/C4 : 10/27/63 |
| US-SRM | 31.821 | -110.866 | WSA | DBS_Te/C3/C4 : 35/43/22 |
| US-Ton | 38.431 | -120.966 | WSA | EBT_Te/C3 : 40/60 |
| US-Whs | 31.743 | -110.052 | OSH | Bare/DBS_Te/C3 : 39/51/10 |

[a] The maximum LAI at the pixel containing the site provided by Reprocessed MODIS version 6.1 LAI. [b] Site-observed data collected in this study. [c] The top layer soil texture (sand/silt/clay) at the site location extracted from the GSDE dataset. [d] Canopy height of the dominant vegetation type at the site from the CoLM lookup table. [e] Specific year of maximum LAI.

***Comment 23 (Figure 2):*** *Don't you mean "number of years", not "site numbers" in the caption for (b)? In (d), is this the actual number of sites or the percentage? The name Hcan is a little confusing, as you talk about sensible heat flux as H above and here H is height.*

**Response 23:** Thanks for your suggestion. In Figure 2 (b), the vertical coordinate is the number of sites, and the horizontal coordinate is the number/length of years.

H (sensible heat) and canopy height ($H_{can}$) do tend to be confusing, so we plan to change the abbreviations for sensible heat and latent heat to Qh and Qle in the manuscript submission after discussions, and the abbreviation for canopy height will remain the same. Thank you very much for your suggestion.

***Comment 24 (L269):*** *Didn't you say that you excluded sites with only one year of data? How can the individual site observations range from 1 to 17 years then?*

**Response 24:** Thanks for your question. We performed a three-step screening process. First, we excluded sites with only one year of observations, as these observations may be unstable. After that, we performed fluxes and VPD screening (details in L122), which may result in some sites meeting the criteria with only one year of observations. Therefore, the range of observations for individual sites varied from 1 to 17 years.

***Comment 25 (Figure 3):*** *I do not see the difference between site and default data for the PCT_PFT. Where is it? This also applies to l. 282. If you have multiple PFTs at the site, is the canopy height the maximum height, the average or an average weighted by the fractions of those PFTs present at the site? The same question also applies to the LAI.*

**Response 25:** Thanks for your question. For PCT_PFT, the default data uses the IGBP classifications (i.e., a single ecosystem type, such as evergreen broadleaf forest (EBF)); the site data is composed of different plant functional types (PFTs). In Figure 3 (a), the asterisk indicates that the site vegetation cover has multiple PFTs, offering a more accurate representation of the vegetation conditions compared to the IGBP classifications.

Due to the availability of data sources, site canopy heights and LAI have not reached the level of PFTs. For the default LAI, the grid LAI is given here, not the LAI of the PFTs. For the default canopy height, we provide the height of the dominant PFT (highest percentage coverage).

In addition, 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 26 (L285):*** *This should be "at certain sites".*

**Response 26:** Thank you for your correction. We have revised it.

**Origin (L285):**

"in certain sites"

**Revised (L285):**

"at certain sites"

***Comment 27 (L292):*** *Rephrase this sentence to make it clearer. Do you mean the file "provides" and what do you mean with "range of years for maximum LAI"?*

**Response *27*:** 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 the year range covered by maximum LAI, and the maximum for a specific year."

***Comment 28 (Table 3):*** *Regarding the Reference height: What about the measurement height of air temperature? That is required by some models as well. It's unclear what you mean with "b Range of years with maximum LAI". If there are multiple LAI measurements, isn't each measurement for a specific year? Otherwise, if it is the maximum LAI of a timeseries, you should make that clearer.*

**Response *28*:** Thank you for your suggestion. As mentioned in comment 13, we have added the reference measurement heights for air temperature and humidity to the attribute dataset.

At some sites, the maximum LAI was reported in different years. Therefore, we used "range of years of maximum LAI" to express it. As per your suggestion, we have modified it to "the year range covered by maximum LAI."

**Origin (Table 3):**

"[b] Range of years with maximum LAI."

**Revised (Table 3):**

"[b] The year range covered by maximum LAI."

***Comment 29 (L318):*** *It is unclear to me what you mean with "were comparatively equilibrated".*

*Rephrase this to make it clearer.*

**Response *29*:** Thank you for your suggestion. I am sorry for the unclear expression. We have reorganized the language.

**Origin (L317):**

"On average, the impacts of four attributes—PCT_PFT, LAI, canopy height, and soil texture—on LE and H were comparatively equilibrated."

**Revised (L317):**

"On average, changes in latent and sensible heat are not dominated by certain attributes. All four attributes—PCT_PFT, LAI, canopy height, and soil texture—have a relatively strong impact on both."

***Comment 30 (L319):*** *"relatively significant" -> Do you mean it is "statistically significant"?*

**Response *30*:** Thank you for your question. We realize that "relatively significant" may not be appropriate. What we are trying to express here is "relatively greater".

**Origin (L319):**

"And the effect of soil texture on LE is relatively significant"

**Revised (L319):**

"And the effect of soil texture on LE is relatively greater"

***Comment 31 (Figure 7):*** *Why do you show SWup and GPP at 2 sites only and don't show the LE and H there? Also, it doesn't seem to show observations for SWup at US-KS2. Why show that variable at that site, if observations were not available? Why were these specific 8 sites chosen for the figure (and not all 36 sites) and why don't you show LE, H, GPP and SWup at all the selected sites?*

**Response *31*:** Thank you for your question. I'm sorry for the confusion. In the modeling assessment of attribute data, four attributes were selected, and Figure 7 shows two typical sites for each attribute (which can be contrasted to highlight the important role of precipitation). We have added this information to the description of Figure 7.

The US-KS2 and US-GLE sites are used to illustrate the role of precipitation in the impact of LAI on model results. Specifically, the result of SWup is more convincing, so we have co-displayed SWup at the US-KS2 and US-GLE sites. Although the US-KS2 site does not have SWup observations, we can still see the difference in the simulations between the site data and the default data.

Figure 7 is intended to illustrate that the impact of attributes is substantially associated with precipitation. We intentionally chose two typical sites for each attribute and formed a contrasting effect to illustrate the important role of precipitation. Therefore, only 8 sites are ultimately shown.

**Origin (Figure 7 caption):**

"and GPP at 8 selected sites"

**Revised (Figure 7 caption):**

"and GPP at 8 selected sites (two sites for each attribute for comparison. PCT_PFT: AU-How and SD-Dem; LAI: US-KS2 and US-GLE; $H_{can}$: IT-Cpz and BE-Vie; Soil texture: FI-Sod and AU-Cpr)"

***Comment 32 (L355):*** *I think it would be good to be more specific what exactly you mean here, as for example different land surface modelling groups pay attention to the site-specific data required to set up sites and many measurement groups collect at least some of the data, but it's not always easily accessible. I think it would be important to point out the need for more site attribute data to be included in flux datasets, etc.*

**Response *32*:** We agree with you, and more importantly point out the need to include more site attribute data in the flux dataset. 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 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 hope that future flux tower datasets will provide standardized site attributes."

***Comment 33 (L369):*** *Why was the model run at only 36 of the sites and how were these sites selected?*

**Response *33*:** Thank you for your question. We selected sites with certain differences between site data and default data for each attribute, and finally got 36 sites. The specific method is as follows (L216): We chose ten sites for each of the attributes—LAI, canopy height, and soil texture—where site data differ the most from default data (In the lookup table canopy height simulations, sites with zero plane displacement exceeding reference measurement height are excluded.). For PCT_PFT analyses, sites with IGBP types that are a combination of trees and grasses (OSH, WSA, SAV) were chosen, resulting in six available sites. These sites were simulated to show the respective impact of different attributes in model results. As a result, 36 sites ended up being used for simulations.

***Comment 34 (L375):*** *Couldn't this also be related to other uncertainties such as in soil textures, soil moisture, thermal and hydraulic conductivities, LAI and GPP affecting canopy evaporation and transpiration? Why focus on the IGBP classification?*

**Response *34*:** Thank you for your question and suggestion. We did lack consideration and only focused on the IGBP classifications (which is also part of the model uncertainties). This result is indeed related to the uncertainties of the model itself as well as other input data. Based on your suggestion, we have modified this sentence. The comparison before and after modification is as follows:

**Origin (L375):**

"This may be related to the model's previous development and evaluation, which was mostly centered on the IGBP classifications"

**Revised (L375):**

"This may be related to the uncertainties of the model itself as well as other input data. Such as the vegetation biophysical parameters, soil thermal and hydraulic conductivities, etc."

***Comment 35 (L376):** What do you mean with "unit LAI variations"?*

**Response *35*:** Thank you for your question and suggestion. "unit LAI variations" means a change in LAI value of 1 m2/m2.

However, according to the comments of reviewer 1, we think the modeling assessment of attribute data has focused primarily on the magnitude of the impact of the attribute data, rather than sensitivity analyses. We believe that this passage may cause some misunderstanding. Therefore, after careful consideration, we removed this part of the argument from the manuscript.

**Delete (L376):**

Notably, unit LAI variations elicit more substantial fluctuations in fluxes at lower LAI values (usually less than 2 m2/m2), according to Launiainen et al. (2016). In light of that, all of the sites we chose have LAI values greater than 2 m2/m2, except US-GLE, the impact of LAI obtained here are relatively minor.

***Comment 36 (L378):** Why did you choose sites with LAI > 2 m2/m2, if the impact is larger at sites with lower LAI? As I'm not sure what you mean with "unit LAI variations", I might be misunderstanding this though.*

**Response *36*:** Thank you for your question. Although we have removed the relevant expression (Response *35*), we feel it is still necessary to explain it clearly to you.

In line 377, we noted that variations in unit LAI elicit more substantial fluctuations in fluxes at lower LAI values (usually less than 2 m2/m2). indicating greater sensitivity of fluxes to LAI. However, this does not imply that their simulation differences are greater. Therefore, we prioritized sites with larger differences in LAI values for modeling assessment (L216).

***Comment 37 (L393):** Which site attributes did they modify and to what extent? What kind of site were they looking at? Also, this might be model specific how sensitive the model is to certain variables. Instead of "a previous study viewed", do you mean "showed"?*

**Response *37*:** Thank you for your question. This study modified the site's soil texture, LAI, and canopy height. Specific numerical changes can be viewed from Table 2 of Ménard et al. (2015). Measurements against which the ensemble was evaluated were collected in two sites situated 60m from one another and describing two land-cover types: one artificial forest clearing and one forest site. Variables assessed in the study included latent heat, sensible heat, soil temperature and moisture, and snow water equivalent. The authors concluded that "differences in ancillary data (attribute data) have little effect on model results".

Based on our experience in the modeling assessment of attribute data, we believe that the model's sensitivity to different variables changes the magnitude of the quantified values, but not enough to change the main conclusions.

Thank you for your correction. We have revised "A previous study viewed". The comparison before and after modification is as follows:

**Origin (L393):**

"A previous study viewed that"

**Revised (L393):**

"A previous study stated that"

***Comment 38 (L397):*** *"Mostly during the growing season" -> This depends. For example albedo differences due to PFT selection can have significant impacts when snow is present (depending on whether snow covers the vegetation or not, etc.).*

**Response *38*:** Thank you for your suggestion. We've revised these words and phrases based on your suggestion.

**Origin (L396):**

"the impacts of attribute data on climate-related variables occur mostly during the growing season."

**Revised (L396):**

"the impact of attribute data on climate-related variables is generally over a period (mostly during the growing season) rather than throughout the year"

***Comment 39 (L402):*** *How exactly are these low-cost? That seems to depend on whether the measurements are already done at a site or not. Especially, measurements that have to be done manually instead of automated can be labor-intensive and thus not inexpensive.*

**Response *39*:** Thank you for your question. We realized we weren't making it clear. It does depend on whether site measurements have been completed. However, the attribute data used in this paper is time-invariant. Only one measurement is required, so these measurements are low-cost.

We have refined this expression to avoid confusion. The comparison before and after modification is as follows:

**Origin (L402):**

"These collections of site attributes are low-cost but would strongly benefit model enhancement."

**Revised (L402):**

"These observations and collections of site time-invariant attributes are generally low-cost but would strongly benefit model enhancement."

***Comment 40 (L405):*** *Why do you make the statement that an increasing array of surface parameters elevates the model to a heightened level of sophistication? New processes and more complexity do not necessarily improve results and increase uncertainty, as many parameter values are not well defined or constrained.*

**Response *40*:** Thank you for your question. We fully agree with you. New processes and more complexity do not necessarily improve results and increase uncertainty. Therefore, these parameters must be clarified.

We apologize for the misunderstanding caused by our wording. We have revised it.

**Origin (L405):**

"sophistication"

**Revised (L405):**

"complexity"

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.

As you indicated, the manuscript still has several unclear expressions. Similar issues have been noted by other reviewers as well. We greatly appreciate the partial corrections you have already provided. After the discussion phase concludes, we will thoroughly review the manuscript for language issues before submission. Once again, thank you very much for the comments and suggestions.

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