

Anonymous Referee #1, 04 May 2026

Report #1

Submitted on 04 May 2026 Anonymous referee #1	
Notes for the submission of interactive comments	
Anonymous: ☒ Yes ☐ No	
Formal manuscript rating and recommendation to the editor (visible to authors and reviewers only)	
1) Scientific significance Does the manuscript represent a substantial contribution to modelling science within the scope of this journal (substantial new concepts, ideas, or methods)?	Excellent Good Fair Poor
2) Scientific quality Are the scientific approach and applied methods valid? Are the results discussed in an appropriate and balanced way (consideration of related work, including appropriate references)? Do the models, technical advances and/or experiments described have the potential to perform calculations leading to significant scientific results?	Excellent Good Fair Poor
3) Scientific reproducibility To what extent is the modelling science reproducible? Is the description sufficiently complete and precise to allow reproduction of the science by fellow scientists (traceability of results)?	Excellent Good Fair Poor
4) Presentation quality Are the scientific results and conclusions presented in a clear, concise, and well structured way (number and quality of figures/tables, appropriate use of English language)?	Excellent Good Fair Poor
For final publication, the manuscript should be ☐ accepted as is ☐ accepted subject to technical corrections ☒ accepted subject to minor revisions ☐ reconsidered after major revisions ☐ rejected Please note that this rating only refers to this version of the manuscript!	
Were a revised manuscript to be sent for another round of reviews: ☒ I would be willing to review the revised manuscript. ☐ I would not be willing to review the revised manuscript.	
Referee Comment: 'Comment on egusphere-2026-551'	

General comments:

This study describes a new one-tile urban scheme in the ORCHIDEE land surface model, which helped improve energy flux simulations and better capture the urban signature in water fluxes at 20 Urban-PLUMBER sites. The manuscript is clearly written and presented, and represents continued efforts by the global community towards improving urban representation in global-scale models. My main concern lies in the significant (up to 200 W/m^2) overestimation of sensible heat flux during the day in summer. As the authors mentioned a few times, the lack of anthropogenic heat fluxes may explain some of the underestimation in sensible heat fluxes in the winter, but similar argument can apply in the summer as well, which means the inclusion of anthropogenic heat flux could further worsen the overestimation of sensible heat flux in summer. Could the authors explain what could be contributing to the significant overestimation of sensible heat in summer during the day? As this bias persists in the original (baresoil), natural vegetation, as well as the urban experiments, could there be reasons linking to model structure or other more fundamental assumptions in ORCHIDEE? Does this overestimation show up in rural/natural vegetation settings as well? Having a detailed description on the potential reasons contributing to the bias could help readers better contextualize and add to the trustworthiness of the model development.

We thank the reviewer for this constructive comment and for their positive assessment of the manuscript.

During the revision, we identified an issue in the experimental setup used for the submitted manuscript: all simulations had been performed using the default ORCHIDEE soil texture rather than the site-specific soil-texture information provided by Urban-PLUMBER. We therefore reran every model configuration (Baresoil, Lowveget, Urban0, Urban1, and Urban2) at all 20 sites using the corresponding site-specific soil texture. These new simulations replace the original simulations throughout the revised manuscript. Consequently, all simulation-based result figures, including the boxplots, diurnal cycles, MAE comparisons, and water-budget analysis, as well as the associated numerical values and conclusions, were recomputed. The changes in the distributions, including the higher minimum latent heat flux values, therefore result from the revised simulations.

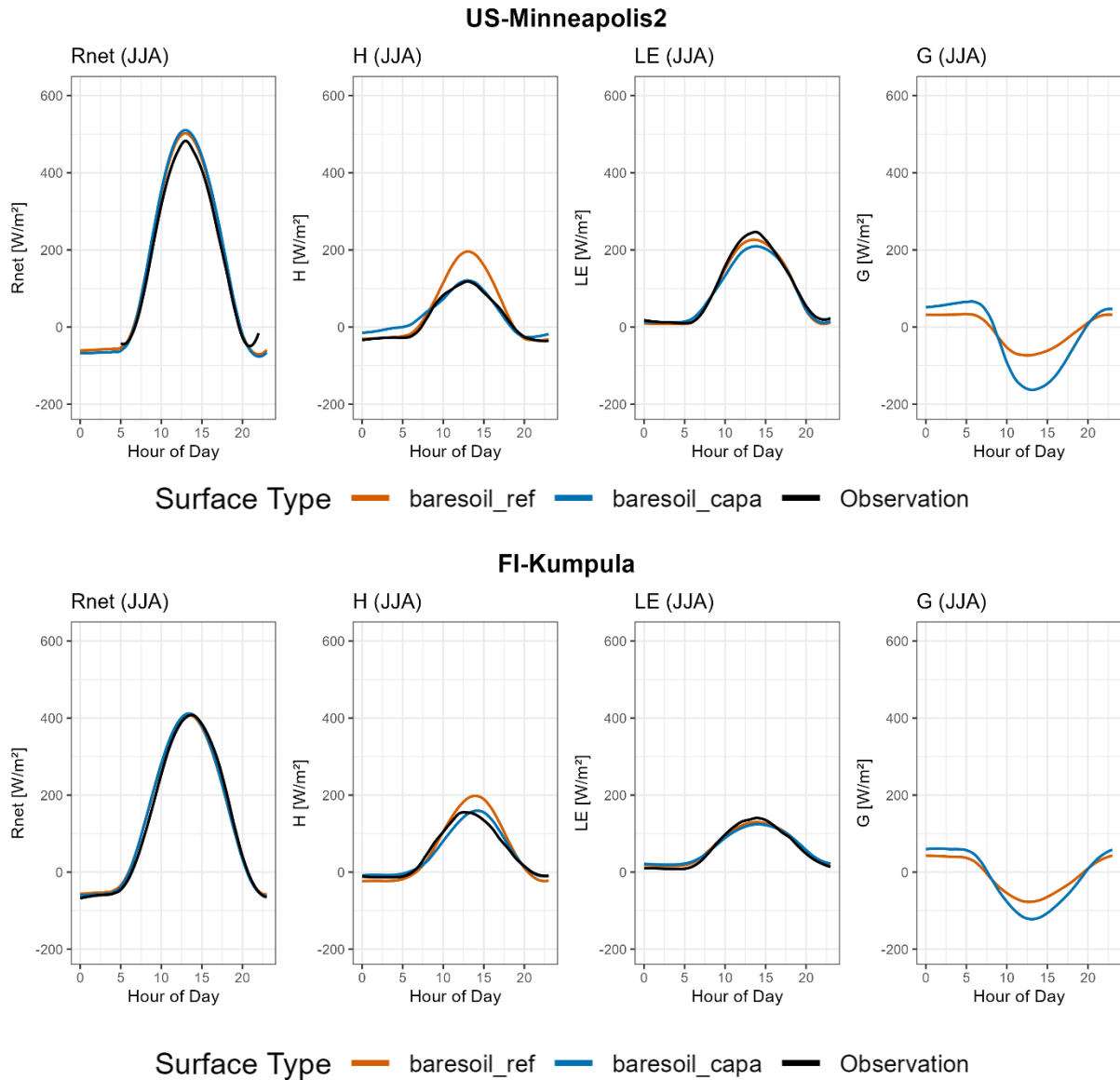
The effect of the soil-texture correction is site dependent: it reduces the sensible heat flux bias at some sites but increases it at others. The remaining large biases therefore cannot be attributed solely to the use of the default soil texture. To investigate these persistent biases, we performed a separate sensitivity experiment in which higher urban thermal conductivity and volumetric heat capacity were prescribed in the Baresoil configuration. This thermal-property experiment is used only as a diagnostic: it is not included in the final model configuration or in the results reported in the revised manuscript. It identifies soil thermal parameterization as an important avenue for future ORCHIDEE development.

Detailed analysis explaining how we figured out the soil texture issue and the identified underestimation of heat capacity and conductivity at semi-urban stations:

The largest biases in the summer mean daily maximum sensible heat for Baresoil occurred at US-Minneapolis2 (228 W m^{-2}), FI-Kumpula (204 W m^{-2}), US-Minneapolis1 (188 W m^{-2}), AU-Preston (183.8), GR-HECKOR (162 W m^{-2}), KR-Ochang (129 W m^{-2}), and US-WestPhoenix (113 W m^{-2}). Importantly, US-Minneapolis1 and US-Minneapolis2 have relatively low urban fractions and are therefore closer to semi-rural sites than to densely urbanized sites (respectively 21% and 5% urban). Moreover, the bias is of a similar magnitude in the bare-soil, natural-vegetation, and urban configurations (except for AU-Preston, where in the Urban configuration, bias decrease to 68 W m^{-2}). This indicates that it is not primarily introduced by the new urban parameterization, but as the reviewer suggested, instead reflects a more general limitation in the representation of surface energy partitioning in ORCHIDEE at these sites.

To investigate the source of the bias, we examined the summer mean diurnal cycles, and we show the results for two sites, US-Minneapolis2 and FI-Kumpula. We focus on the

baresoil simulation because the magnitude and timing of the bias are similar across the different model configurations. The corresponding figures are provided below.



The reference simulations, shown by the orange curves, indicate that the excessive daytime sensible heat cannot be attributed to an equivalent positive bias in net radiation or to the small underestimation of latent heat flux. Instead, the energy partitioning suggests that the simulated daytime ground heat uptake is too weak, leaving an excessive fraction of the available energy to be released as sensible heat. Although uncertainties related to observational energy-balance closure must also be considered, this result points towards the representation of soil heat storage and ground heat flux as an important contributor to the bias.

As a sensitivity test, we replaced the default soil thermal conductivity and volumetric heat capacity with the values used for urban surfaces in the new scheme (in the standard urban configuration, these values are applied only when the urban fraction exceeds 50%, this criterion is not met at US-Minneapolis2 or FI-Kumpula). For the sensitivity

experiment, the urban thermal properties were instead prescribed throughout the bare-soil simulation. The resulting simulations are shown by the blue curves.

This modification substantially reduces the daytime summer QH bias at most of the affected sites. For example, the bias decreases from 228.3 to 103.8 W m⁻² at US-Minneapolis2, from 188.1 to 68.0 W m⁻² at US-Minneapolis1, from 161.7 to 38.7 W m⁻² at GR-HECKOR, and from 128.9 to 5.6 W m⁻² at KR-Ochang. The complete results are shown below.

Site	Bias in summer daily max Qh (W m ⁻²)		
	Baresoil_ref (1st version result)	Baresoil_capa (change of soil capacity)	Revised with soil texture (new results, in revised manuscript)
AU-Preston	183.8	115.9	169.7
AU-SurreyHills	54.3	33.2	47.6
CA-Sunset	9.2	-109.6	25.5
FI-Kumpula	203.5	141.6	77.0
FI-Torni	82.2	41.5	-26.4
FR-Capitole	81.5	-57.2	78.6
GR-HECKOR	161.7	38.7	171.0
JP-Yoyogi	57.3	-29.1	25.0
KR-Jungnang	-10.8	-114.5	15.1
KR-Ochang	128.9	5.6	113.3
MX-Escandon	88.8	6.8	90.6
NL-Amsterdam	23.3	-16.2	43.5
PL-Lipowa	105.0	9.2	141.4
PL-Narutowicza	79.7	-22.0	100.0
SG-TelokKurau06	54.8	1.7	64.0
UK-KingsCollege	19.5	-78.7	38.2
UK-Swindon	8.7	-73.2	9.7
US-Baltimore	21.6	-64.2	29.8
US-Minneapolis1	188.1	68.0	144.4
US-Minneapolis2	228.3	103.8	168.9
US-WestPhoenix	112.6	-44.3	109.7

These sensitivity experiments strongly implicate the representation of subsurface thermal properties, particularly soil thermal conductivity, as an important source of the positive sensible heat bias. In the standard model, thermal conductivity and heat capacity are calculated from soil texture class and state variables, including porosity, soil moisture, liquid water content, and quartz fraction. The use of a limited number of broad soil texture classes, together with uncertainty in these state-dependent relationships, can produce substantial errors in simulated ground heat storage. This limitation is not specific to ORCHIDEE and is increasingly recognized within the land-surface modelling

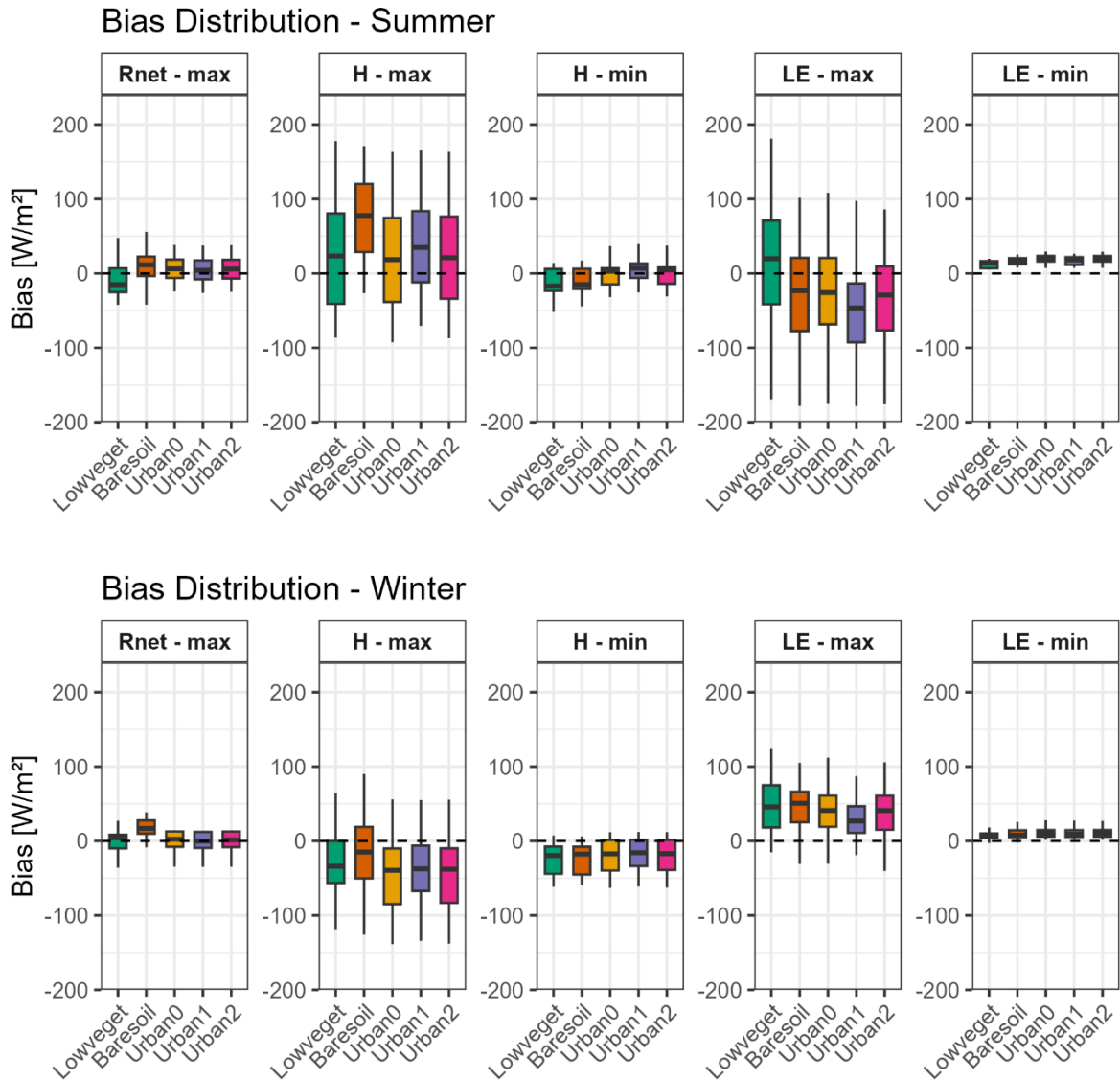
community, as discussed by Verhoef et al. (2026). A comprehensive revision of soil thermal parameterization is beyond the scope of the present urban-scheme development, but these results identify it as an important priority for future ORCHIDEE development.

We have added a discussion of this limitation to the revised manuscript:

“Still, all simulations tend to overestimate sensible heat, the bias exceeding 150 W m^{-2} at some stations. The largest summer sensible heat flux biases are common across the baresoil, vegetation, and urban simulations. Additional sensitivity experiments indicate that they are partly related to underestimated ground heat uptake associated with the representation of soil thermal properties: prescribing higher thermal conductivity and heat capacity substantially reduces the biases at most affected sites, all of which have urban fractions below 50%, highlighting soil thermal parameterization as an important target for future ORCHIDEE development (Verhoef et al., 2026).”

Finally, we revised the manuscript describing the results of our new simulations which now account for soil texture information from the Urban-plumber data (indicated in Table 1 of the manuscript), which changes some of the model outputs and performances:

New figure 3:



We adapted the description and analysis of the figure in consequence:

“The different parameterizations used in the model configurations lead to the largest differences for the maximum daily sensible heat flux. During the summer, the Baresoil simulations have a more pronounced overestimation compared to the urban simulations, showing a median bias close to 77 W m^{-2} . In contrast, the Urban0 and Urban2 simulations have a bias distribution centered closer zero (respectively having a median bias of 14 and 18 W m^{-2}), and 50% of biases between 66 and -36 W m^{-2} . The substantial change in simulated sensible heat is due to increased thermal conductivity in urban simulations, as already seen in Fig. 2. However, many simulations do not match the maximum daily observed sensible heat as closely as for AU-Preston, although the biases are significantly reduced. The Urban2 simulation introduces only minor changes compared to the Urban0 simulation for sensible heat. Urban1, on the other hand, increases the bias compared to Urban0 and Urban2 during summer, but still brings improvement compared to Baresoil. Still, all simulations tend to overestimate sensible heat, the bias exceeding 150 W m^{-2} at

some stations. The largest summer sensible heat flux biases are common across the baresoil, vegetation, and urban simulations. Additional sensitivity experiments indicate that they are partly related to underestimated ground heat uptake associated with the representation of soil thermal properties: prescribing higher thermal conductivity and heat capacity substantially reduces the biases at most affected sites, all of which have urban fractions below 50%, highlighting soil thermal parameterization as an important target for future ORCHIDEE development (Verhoef et al., 2026). In winter, maximum daily sensible heat is generally underestimated across the simulations. Baresoil has the least negative bias, although its bias distribution remains relatively broad, while Lowveget and the Urban simulations show similarly negative biases. This similarity suggests that the winter underestimation of sensible heat cannot be primarily attributed to the increased thermal conductivity introduced in the urban configurations. At the same time, all simulations show a positive bias in maximum latent heat flux, indicating that excessive partitioning of the available energy toward latent heat may contribute to the negative sensible heat bias. The absence of anthropogenic heat fluxes from the simulations may additionally contribute to the underestimation at some highly urbanized sites. For example, Urban-PLUMBER reports mean anthropogenic heat fluxes of 78.5 W m^{-2} at UK-KingsCollege and 92.7 W m^{-2} at KR-Jungnang.

Minimum sensible heat flux, which corresponds to the nocturnal sensible heat flux, is generally higher in cities than in natural areas due to the release of stored heat accumulated during the day and the persistence of heat transfer by convection at night. As expected, both in winter and summer, Baresoil and Lowveget simulations exhibit a negative bias, meaning they simulate nocturnal sensible heat that is too low. The Urban0, Urban1, and Urban2 simulations lead to improvements in the simulation of nocturnal sensible heat flux. Furthermore, the Urban1 simulation, which includes stronger imperviousness, further improves the representation of nocturnal sensible heat during both seasons. Still, Urban0, Urban1, and Urban2 show negative bias in minimum sensible heat fluxes in winter. This underestimation is unlikely to be primarily explained by latent heat flux, for which nighttime biases remain comparatively small. It may instead partly reflect an insufficient release of stored heat at night, as well as missing anthropogenic heat fluxes at highly urbanized sites.

Looking at maximum latent heat flux, Fig. 3 shows a clear seasonal contrast. In winter, biases are positive for all simulations, indicating an overestimation of daytime latent heat flux. In summer, biases are instead generally negative, indicating an underestimation of maximum latent heat flux, although the distributions remain broad and span both positive and negative values across stations. The summer underestimation may partly result from an insufficient representation of active vegetation and from the absence of irrigation in the model. This interpretation is supported by the Lowveget simulation, whose median summer bias is close to zero and which also shows a maximum sensible heat flux bias centered around zero. However, the distribution of Lowveget latent heat biases remains very broad across stations, suggesting that highly local factors such as vegetation

characteristics, vegetation management, and irrigation, which are not explicitly represented by the model configuration, strongly influence latent heat flux. The Urban0 and Urban2 simulations show only limited differences compared with Baresoil. In contrast, Urban1, with stronger imperviousness and therefore lower water availability for evapotranspiration, further increases the summer underestimation while reducing the winter overestimation. Biases in minimum latent heat flux are comparatively small but consistently positive in both seasons across all simulations, indicating an overestimation of nocturnal latent heat flux.

Overall, the urban configurations improve the representation of the surface energy balance through both a better simulation of net radiation and changes in energy partitioning. In summer, the large overestimation of maximum sensible heat flux in Baresoil appears to arise from combined biases: net radiation is imperfectly represented, while both daytime heat storage and latent heat flux are underestimated, leaving too much of the available energy to be transferred as sensible heat. The Urban configurations improve net radiation and substantially improve the representation of daytime heat storage, which strongly reduces the sensible heat bias. Maximum latent heat flux, however, remains generally underestimated, suggesting that evapotranspiration, including the representation of local vegetation characteristics and irrigation, is an important remaining source of error. In contrast, the Urban configurations do not improve sensible heat in winter, they exhibit a systematic underestimation of maximum sensible heat, consistent with an overestimation of maximum latent heat flux. Despite this limitation, the urban configurations systematically improve nocturnal sensible heat in both seasons relative to Baresoil and Lowveget.”

To summarize, we have rerun the simulations with soil texture information, which changes the performance of the model. It improves the energy balance over some stations and deteriorates it over other stations, but it highlights better the overestimation of sensible heat in summer resulting from an underestimation of latent heat, and the underestimation of sensible heat in winter resulting from a too high latent heat. The rest of the manuscript results (MAE, water balance), are also re computed based on these new simulations.

Specific comments/Technical corrections:

L19: perhaps missing a noun after “high-resolution convection-permitting”?
“Applications” or “simulations”?

Done

L81: Define PFTs here as it is the first time it appears in the text.

Done

L85: Missing “of” between “the geometry” and “buildings and streets”.

Done

L87: “cities buildings” should be “buildings in cities”.

Done

L92: The comma is not needed.

Done

L196: λ_s and λ_w should be given units as well. Also, the comma after “solid soil” is not needed.

The units are ($\text{W m}^{-1} \text{K}^{-1}$), we added them again after λ_s and λ_w to make it more evident as suggested by the reviewer.

L239 - 241: This sentence seems to be grammatically incorrect. Perhaps rewrite “ $f=2m$ ” into “ f is set to $2m$ ”?

We updated the text as:

“ f is set to 2 m^{-1} ”

Eq. (17): “ β ” should be “ βET ”

Done

L261: and becomes closer to zero as soil moisture gets limiting

Done

L262: the different ET components

Done

L385: refer readers to Figure 2 here.

Done

Figure 3: describe in the caption what each element of the boxes represents (e.g., 95th percentile, 75th percentile, etc.).

We added in the caption:

“For each boxplot, the central horizontal line indicates the median, the lower and upper edges of the box indicate the 25th and 75th percentiles, respectively, and the whiskers extend to the most extreme values within 1.5 times the interquartile range (IQR). The dashed horizontal line indicates zero bias.”