Reply on RC1

Replies to the Reviewers' remarks

We thank all the Reviewers for the careful revisions and the constructive comments to our work. All suggestions have been appreciated and have been taken into careful consideration in our revision. Below, we provide a detailed reply to all points raised by the reviewers.

Referee: 1

1) It is not clear if the MLUCM BEP+BEM is coupled to a land surface model to simulate land-atmosphere interactions for natural/rural surfaces. What are the sources of latent heat in BEP+BEM? How is the grid-averaged latent heat flux estimated?

R: In order to clarify this point the following sentence has been added to the manuscript in line 157-162:

"MLUCM BEP+BEM is not coupled with an external land surface model. The latent heat flux results from the weighted average of contributions from natural (e.g., green road fractions and street trees.), and wet built surfaces (water from rain on road and roofs). For the green road fraction, the same scheme adopted by green roofs, described in Zonato et al. (2021), is used. For the trees, the latent heat flux is estimated using a simple empirical parameterization that partitions the radiation absorbed by leaves into sensible and latent heat."

2) Have the street-canyon-trees and street-canyon-gardens models been validated in a previous work? Are trees and gardens (in the street canyon) the unique sources of latent heat in these simulations?

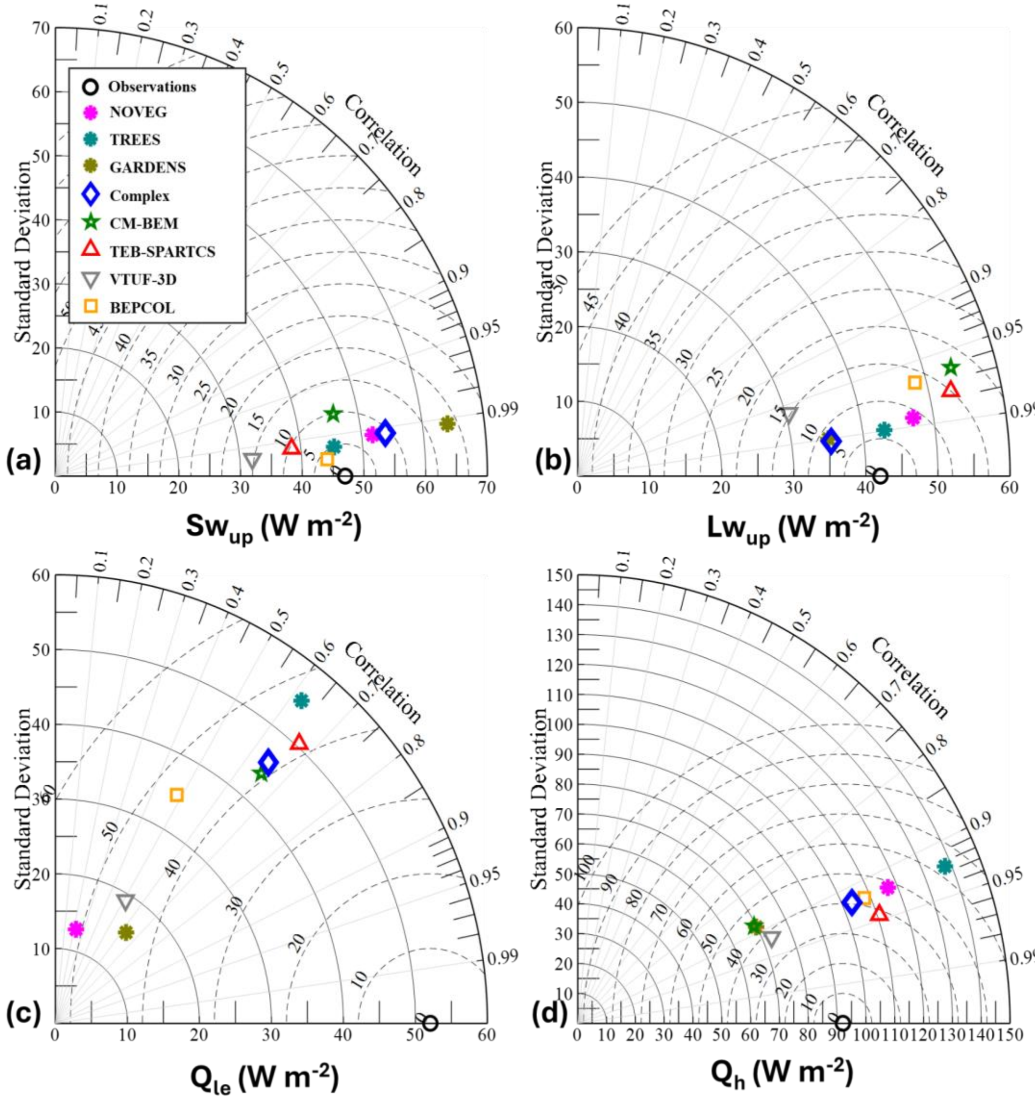
R: The street-canyon-trees and street-canyon-gardens models, although previously proposed and applied in the studies of Stone et al., (2021) and Zonato et al., (2021), respectively, had not been validated with respect to the latent heat flux. While the street-canyon gardens model is inspired by the parameterization proposed by De Munck et al. (2013), which was validated in their original study, the street-canyon trees model has not undergone specific validation until now. The results presented in this study are the first direct validation against in situ observations of latent heat flux and show a quality comparable to other models.

Street-canyon-trees and gardens are the main latent heat source in the three experiments analyzed in this study, but these simulations also consider the contribution from artificial wet surfaces. Further our model can include other sources, such as air conditioning systems and green roofs (not active in the simulations presented in this paper), as well as evaporation of rain water accumulated on roofs and roads.

de Munck, C. S., Lemonsu, A., Bouzouidja, R., Masson, V., and Claverie, R.: The GREENROOF module (v7.3) for modelling green roof hydrological and energetic performances within TEB, Geosci. Model Dev., 6, 1941–1960, https://doi.org/10.5194/gmd-6-1941-2013, 2013.

3) Table 1 shows that tree area fraction is 0.225 for this neighborhood. How do sensible and latent heat fluxes change when this fraction is set to 0? In other words, is the role of trees important for mesoscale simulations? Was the impact of trees on near-surface air temperature and/or specific humidity modeled in the numerical experiments?

R: Simulations were conducted for the “complex” experiment, considering three scenarios: one including only street trees (referred to as **TREES**), one including only gardens (**GARDENS**), and one excluding both types of vegetation (**NOVEG**). These configurations were designed to address this and the following research question. Additionally, we identified an error in the previously used tree area fraction value of 0.225. This value should have been weighted by the street fraction according to the model’s infrastructure settings. For further clarification, please refer to the general comment, also provided in response to Reviewer 2. The interpretation of the changes of variability in the Taylor results indicates that excluding trees significantly reduces the latent heat flux and at the same time it decreases the reflected shortwave flux. Concerning the sensible heat flux the latter effect prevails determining its increase.
Near-surface air temperature and humidity measurements are not included in the Urban-PLUMBER protocol, making it difficult to establish a reliable reference for validating model output and answering the last question of the Reviewer.



Q_{le}				
	Complex	NOVEG	TREES	GARDENS
BIAS	-4.60	-28.62	-0.69	-22.49
NME	0.88	5.11	0.86	2.58
SLOPE	0.56	0.05	0.66	0.19
COR	0.64	0.22	0.62	0.65
Q_h				
BIAS	17.86	21.76	26.6	6.28
NME	0.48	0.47	0.48	0.64
SLOPE	1.03	1.17	1.39	0.67
COR	0.92	0.92	0.92	0.89

4) Similarly, table 1 shows that grass area fraction is 0.15 for this neighborhood. How do sensible and latent heat fluxes change when this area fraction is set to 0? Was the impact of grass area fraction on near-surface air temperature and/or specific humidity modeled in the simulations?

R: The interpretation of the changes in variability in the “GARDENS” simulation in the Taylor results (olive stars) indicates that excluding gardens reduces the latent heat flux (but to a lower extent than excluding trees) and has a small effect (increase) on the reflected shortwave flux. The sensible heat flux decreases to compensate for the increased latent heat.

5) Overall, the baseline experiment produced good results compared to the other two experiments, which could indicate that some urban parameters are more important than others to accurately simulate the urban climate. Could you explain what is the added value of considering site-specific observations for six/seven additional urban parameters (compared to the baseline experiment) for mesoscale climate simulations?

R: The results indicate that “detailed” and “complex” experiments, incorporating more detailed morphological parameters, lead to better estimates of sensible and latent heat flux, often exhibiting smaller errors than the “baseline” experiment.
However, the added value of incorporating detailed urban descriptors would become evident when addressing aspects such as building energy demand or the effectiveness of urban mitigation strategies (which are not considered in this study that refers to the Urban-PLUMBER protocol). As emphasized in previous work (Pappaccogli et al., 2021), accurately representing urban morphology, particularly the volumetric structure of the built environment and the exchange surfaces between built-up areas and the urban boundary layer is crucial for simulating energy demand. This is directly linked to anthropogenic heat emissions, which are a key component of urban climate dynamics.

Additional clarification has been included in the Section 5 of the manuscript in lines 460-463 as follows:

"*Results show that the integration of detailed, site-specific information on urban elements such as building geometry and vegetation generally improves the simulation of energy fluxes. This level of detail is particularly important for applications involving building energy demand or urban mitigation strategies, where accurate representation of urban morphology, especially the volumetric structure, is essential (Pappaccogli et al., 2021).*"

Pappaccogli, G., Giovannini, L., Zardi, D., & Martilli, A. (2021). Assessing the ability of WRF-BEP + BEM in reproducing the wintertime building energy consumption of an Italian Alpine city. Journal of Geophysical Research: Atmospheres, 126, e2020JD033652. https://doi.org/10.1029/2020JD033652

General comments for reviewer 1

The Reviewers' comments offered an opportunity to conduct a more in-depth investigation into the representation of latent heat flux in our model. This led to the discovery of a significant error: the tree and garden area fractions used in the three experiments were only 55% and 76%, respectively, of the correct values. This discrepancy systematically underestimated both the magnitude and variability of the latent heat flux.
Furthermore, the recently proposed UT-GLOBUS database by Kamath et al. (2024) was employed to enhance the representation of building distributions in the "complex" experimental setup, producing a generalized increase of the height of buildings. These two changes have led to a reduction of the negative latent heat bias of our former simulations. The updated simulations yield results that are consistent with those obtained from similar parameterization schemes.

Additional clarification has been included in the manuscript in lines 277-278 as follows:
"*For the "complex"* experiment*, the UT-GLOBUS database (Kamath et al., 2024) was employed to derive this parameter.*"

Please note that Sections 4.1 and 4.2 have been completely rewritten in the revised manuscript to fit with the results of the new simulations.

Kamath, H.G., Singh, M., Malviya, N. et al. GLObal Building heights for Urban Studies (UT-GLOBUS) for city- and street- scale urban simulations: Development and first applications. Sci Data 11, 886 (2024). https://doi.org/10.1038/s41597-024-03719-w