Response to Anonymous Referee #1

S. Karttunen, M. Sühring, E. O'Connor, and L. Järvi

Anonymous Referee #1 comment
Authors' response

The authors have well responded to the reviewers comments and clarified the novelty of their work. Some minor issues remain.

We thank the reviewer for agreeing to re-review the manuscript and for the comments provided.

- Concerning the statement related to indoor air temperature and transmitted solar radiation: "It is used as a boundary condition in the subsurface energy balance as mentioned in Section 2.6. The transmitted SW radiation does not modify this value". This sounds as if energy is not conserved. It would be possible to diagnose the energy created/destroyed due to this modelling approach and potentially add it to the sensible heat flux. Could you please explain this a bit better and/or make a small model change?

We agree with the observation that the current implementation of the indoor air boundary condition does not strictly speaking conserve energy. The indoor energy fluxes due to both conduction and radiation are recorded as outputs, but do not affect the indoor air temperature. Modelling the indoor temperature would involve either coupling PALM-SLUrb with an indoor heat model.

With an absence of such coupling, the indoor temperature is currently given as an user input. Such modelling boundaries, where energy is not conserved, exist also elsewhere in the PALM model system where fixed-value (as per user input) boundary conditions are utilised. In the case the user requires dynamically changing indoor air temperature for their application, PALM-SLUrb allows for temporally dynamic input of the indoor temperatures based on e.g. measurement data or data from other models.

Although PALM already includes a coupled HVAC mode, it is targeted towards grid-resolved buildings and cannot be simply reformulated for parametrised urban canopies as assumed in SLUrb. Adapting the indoor model would include extensive development work. Meanwhile, on the time scales of a typical LES simulation and due to the relatively small specific heat capacity of air compared to solid structures, we do not expect using a user-defined indoor air boundary condition to have a significant impact on the modelling results. As shown in our sensitivity tests, a 2 K increase in the indoor temperature caused an increase of 1.45 W m^{-2} in the urban-aggregated sensible heat flux and an increase of 0.02 K in the 2-metre air temperature within the street canyon. However, the impacts will be more significant in longer simulations.

We acknowledge the need to address this matter and limitation better in the manuscript. For this, we added an additional paragraph in Section 5 (L795-804).

- L87: intergrated

We thank the reviewer for spotting this. We have corrected the spelling.

Response to Anonymous Referee #3

S. Karttunen, M. Sühring, E. O'Connor, and L. Järvi

Anonymous Referee #3 comment
Authors' response

This study presents the development of a single-layer urban canopy model, based on the Town Energy Balance approach, for the PALM large-eddy simulation model, referred to as PALM-SLUrb. This model enables the PALM modeling framework to perform large-eddy simulations (LES) coupled with a single-layer urban canopy parameterization, without relying on the self-nesting strategy typically required in the PALM-4U system for simulating megacities with huge urban coverage and avoiding the complications associated with partially resolved urban features in intermediate-resolution domains.
By integrating a computationally efficient urban canopy model with a high-resolution LES system, this work helps in bridging the gap between fully resolved 3D urban canopy models, which are computationally expensive, and overly simplified urban parameterizations. As a result, it expand the applicability of the PALM modeling framework to a wider range of urban climate studies.

Although the validation presented is relatively simple, focused on experiments aimed at verify numerical correctness of the implementations rather than realistic urban scenarios, the results demonstrate that PALM-SLUrb performs satisfactorily when compared to fully building-resolved simulations. This supports growing evidence that simplified urban canopy models, (as suggested in the intercomparison work by Lipson et al., 2023 and noted by the authors) can deliver competitive accuracy at significantly lower computational cost.
In general, the paper is well written and detailed, with all equations clearly presented, as expected for a technical journal like GMD. The limitations of the model ("At the current stage, SLUrb should be considered an experimental model, meaning it has not yet undergone comprehensive testing and evaluation against a wide range of empirical data across diverse scenarios") are clearly stated, and the future work needed to improve the current state of PALM-SLUrb is thoroughly described. Finally, I think that all comments from the previous reviewers have been properly tackled. I therefore recommend the manuscript for publication, after addressing minor remarks described in the attached report.

We thank the reviewer for the time the reviewer has invested in reviewing our manuscript as well as for the comments and suggestions given.

- -Line 97: Please change the reference, as the implementation of the bulk urban canopy parameterization TERRA_URB in the ICON atmospheric model system capable of running LES simulations, has now been published by Campanale et al. (2025): Campanale et al., Investigating urban heat islands over Rome and Milan during a summer period through the TERRA_URB parameterization in the ICON model, Urban Climate, Volume 60, 2025, 102335. ISSN 2212-0955. https://doi.org/10.1016/j.uclim.2025.102335.

We thank the reviewer for pointing us to this paper. The reference has now been updated.

- in the development outlook, the authors could dedicate a few lines to how they plan to evaluate the model against observations in real city-scale experiments in future works.

Currently, some of the authors of this paper are involved and assist in ongoing studies where PALM-SLUrb is used at city-scale and evaluated against real-world observations. However, we do not want to make any definite claims about the experimental setups in the studies, as it will be up to the primary authors of those studies how they do this. Instead, we added examples of possible evaluation strategies in Section 5 (L828-831).