Point-by-point response for the comments of reviewer #2

General

This study investigates the differences between radiative flux density received by urban surfaces and meteorological parameters (wind and potential temperature profiles) for different degrees of complexity of the radiation modelling in the building resolving urban climate model PALM 6.0. The analysis is made for clear-sky summertime conditions and one idealised and a real urban configuration (a 1 km x 1 km domain located in Berlin, Germany). The results indicate that a relatively high degree of complexity of the radiation modelling is required, considering the sky-view factors of individual facets, the view factors between different facets, urban vegetation, and at least one reflection. Only the interaction of vegetation with reflected radiation and/or the multiple reflections might be omitted without generating too large errors in the relevant prognostic variables. This study deals with an important topic and is conducted using the cutting-edge urban climate model PALM. The study is conducted with rigour, and the methodology and presentation of the results are generally clear. There are however, some potential issues that need to be resolved before the study can be published. I therefore recommend publication after major revisions have been made.

> **Response**: *Thank you for your evaluation. We considered both major and minor revisions you raised and improved the manuscript accordingly.*

Major comments

1) The downwelling longwave flux density of ∼150 W/m 2 (sky temperature ∼220 K) for the idealised urban configuration is suspiciously low and seems unrealistic for a summer day. It is also in noted contrast with the value for the realistic urban configuration, which looks much more plausible. I suspect that water vapour content has been set to 0.0 for the idealised configuration (?). Although such low LW values might be possible on a summer day, e.g. in a very dry area, I consider that they are too far from typical values to be used. The choice of the value for the downwelling longwave radiation will change the results of the study, since for example the effect of the tree absorption depends on the difference between the effective sky temperature and the leave temperature. I therefore propose to redo the simulations using a typical mid latitude summer daily cycle of downwelling longwave radiation.

> **Response**: *The water vapour content is set to 0.0 for the idealised urban configuration. Based on your recommendation, all the simulations of the idealized urban configuration have been simulated again to reflect a typical mid-latitude summer day. All respective figures have been changed in the revised*

manuscript. The general conclusions of the study, concerning the importance of radiative transfer processes, did not change.

2) For the comparison of the different Radiative Transfer Models (RTMs), the meteorological parameters are also allowed to vary. This introduces a feedback since the longwave radiation depends on the surface and air temperature. It would be more rigourous to make a pure comparison of the RTMs, keeping the flow (wind and temperature) completely identical. This analysis should be followed by a second set of coupled simulations, allowing to investigate the changes of the meteorological conditions in the urban canopy layer for the different RTMs.

Response: *We agree that adding more simulations in which meteorological conditions are fixed, and hence the boundary conditions of the radiation model, i.e. RRTMG, would provide a kind of 'pure' comparison of the different RTMs. However, the paper would be, in this case, quite long. For this reason, we limited the study to the coupled simulations. We believe that the coupled simulations are practical since the RTMs will be used within PALM coupled with the radiation model and, in this setup, they will introduce feedback to the meteorological conditions. We pointed out this very important point in the revised manuscript at Page 20, lines 18-20.*

3) There are some restrictions based on the choice of the urban configuration and parameters that should also be named: 1) the building height is homogenous in the simple urban configuration, therefore the differences of radiation incident on the roofs are zero. 2) the albedo of 0.1 is quite low, the effect of neglecting SW (multiple) reflections might be higher for other cases. 3) Trees are lower than buildings, thus potentially underestimating the vegetation effect.

Response: *Thank you for pointing this out. We now highlight these restrictions in the discussion part of the idealized urban configuration in the revised manuscript on page 15, lines 23-26. Concerning point 2, the low value of albedo, we took the chance that we re-simulated all these cases and changed the value to be 0.15.*

4) An alternative to RTM_01 could be to partition the incoming radiation in an equal manner between all the urban surfaces. E.g. all surfaces (horizontal and vertical) receive the downwelling SW flux density divided by the total urban surface divided the horizontal urban surface. This would be as computationally cheap as RTM_01, and maybe deliver better results.

Response: *Thank you for this suggestion. We revised the parameterization of RTM_01 so that all surfaces, including the vertical surfaces, receive average*

radiation flux density and we re-simulated the relevant cases accordingly. The received radiation is changed based on the new parameterization.

5) Concerning the flow conditions, it seems from Fig. 24 that there is no turbulence except the one that is produced due to the presence of the obstacles (e.g. e is close to 0.0 above the buildings in the neutral case). This is not very realistic and might influence the conclusions from the study. Furthermore, the information on how the reference values of velocity and temperature are calculated seems to be missing.

Response: *The turbulence profile of the neutral case is corrected so that the values are not representing only the subgrid-scale turbulence kinetic energy but also the resolved energy perturbations. We added the information on how the reference velocity and temperature are calculated on the respective figures captions.*

6) The violin plot figures could become much more informative if the difference surfaces (ground, walls, roofs) would be distinguished by different colors or symbols.

Response: We *agree. Now, we use different colors for ground, wall, and roof surfaces in the violin plots.*

7) There is an excessive number of figures. Some could be omitted, since they show only very small differences. E.g. 7b, 9a, 11a, 15, 16. Other figures might be regrouped.

Response: *We agree. Figures* 7b, 9a, 11a, 15, 16 have been removed.

8) The titles of the figures (e.g. "(a) Changes in SW radiation flux") should be above the respective figures.

Response: *We agree. Titles are set above the figures*.

8) The wording "irradiance" and "radiative flux density" is used alternately. Is this on purpose? Otherwise, if always the same physical quantity is meant, it should be homogenised.

Response: *We agree. Irradiance and radiative flux density are homogenised since they are used in the manuscript with the same meaning. We used "irradiance" in the revised manuscript.*

8) There is a mix between British and American English.

Response: *We agree. The manuscript is revised based on the English guidelines and house standards of GMD. So, the British English with Oxford spelling, using -z- variants instead of -s-, is used throughout the manuscript.*

Minor comments

- Page 1, L6: "the the PALM model".

Response: *We agree and fixed this in the revised manuscript.*

- Page 1, L7-L10: this is a mix between methodology and results. It might be better to separate them.

Response: *We agree and fixed this in the revised manuscript by moving the methodology related text to the methodology section.*

- Page 1, L13-14: here the processes that need to be considered / could be neglected should be named explicitly.

Response: *We agree. The processes are now explicitly mentioned.*

- Page 1, L16: "urban environment".

Response: *Agreed and fixed.*

- Page 2, L6: unclear what is "large configurations".

Response: *Large configuration means here large domain in size. We replaced "configurations" by "domains" to make it clear that the spatial size of the simulated domains is meant.*

- Page 3, L2: within an urban area.

Response: *Agreed and fixed.*

- Page 4, L25: what means "in the vicinity of vegetation"? Should it not be "in the presence of vegetation"?

Response: *It means "in the existence of vegetation". We replaced it by "in the presence of vegetation" in the revised manuscript.*

- Page 4, L27: "infinite reflections".

Response: *Agreed and fixed.*

- Page 5, L4: "the diffuse downwelling SW and LW fluxes" (?)

Response: *Agreed. However, the RTM requires both components of SW radiation, i.e. the direct and the diffuse components. This part of the sentence is changed accordingly.*

- Page 6, Table 1: - Unclear what is meant by "receiving radiation from surface emission". - Single reflection: is it SW and/or LW? - Multiple reflections: is it SW and/or LW?

Response: *"receiving radiation from surface emission" means that surfaces are allowed to receive LW radiation from other surfaces' heat emission. Reflection, both single and multiple reflections are for SW and LW. We edited this information to the table to make it clear.*

- Page 6, L7: "vertical surface reveive no radiation". For SW, this is clear, but for LW it should rather be stated that the net LW radiation is assumed to be 0.0 W/m^2.

Response: We agree. However, *based on your major comment No. 4 the parametrization of RTM_01 is changed so that surfaces receive average radiation.*

- Page 7, L2: "subprocess" -> "RTM"?

Response: *Agreed and fixed.*

- Page 7, L7: "transferred to air": how is it partioned between sensible and latent heat flux?

Response: *The question of partitioning of turbulent heat fluxes at leafs goes beyond the scope of our manuscript, we here refer to the RTM- and PALM-overview paper where this is described in more detail (Maronga et al. 2019). To briefly describe how the partitioning works here: heat fluxes are calculated from the net radiation balance of the canopy cell. From the net radiation, the latent heat flux is computed, which is the evapotranspiration multiplied by leaf-area density, while evapotranspiration in turn is computed according to the Jarvis–Stewart method, see Stewart (1988) citation in Krc (2021). The sensible heat flux is then defined as the residual, neglecting any storage. We added a sentence to the manuscript on this topic.*

- Page 7, L13: maybe shift "additionally to the SVFs" to be beginning of the sentence.

Response: *Agreed and moved accordingly.*

- Page 8, L16: "Fortunately". Don't use such emotional expressions

Response: *Agreed and removed.*

- Page 8, L20: vegetation partially absorbs.

Response: *Agreed and removed.*

- Page 9, L5: 24 trees in total.

Response: *Agreed and corrected.*

- Page 9, L6: Lalic et al. (2013).

Response: *Agreed and corrected.*

- Page 9, Eq. 3: division by zero if z=h.

Response: *Since z is the height of a cell defined at its center, z is always less than h. We added the definition of z to the revised manuscript.*

- Page 11, L4: "to initialize".

Response: *Agreed and corrected.*

- Page 11, L5: to reduce the computational load.

Response: *Agreed and corrected.*

- Page 13, L5: is it not the difference of the received radiation?

Response: *We agree. We added that this increased radiation is relative to the previous step.*

- Page 14, L3: all surfaces receive radiation.

Response: *Agreed and corrected.*

- Page 14, L30: the surfaces.

Response: *Agreed and corrected.*

- Page 14, L30: especially roof surfaces receive no ... .

Response: *Agreed and corrected.*

- Page 15, L1: receive less LW.

Response: *Agreed and corrected.*

- Page 15, L5: reflected radiation (?)

Response: *Agreed and corrected.*

- Page 15, L17: change more in the realistic case ...

Response: *Agreed and corrected.*

- Page 15, L19: secondly (?)

Response: *Agreed and corrected.*

- Page 15, L19: higher than for the ...

Response: *"those" in "higher than those" refers to "the changes" in the beginning of the sentence. We changed it to be clear in the revised manuscript.*

- Page 15, L26: thirdly (?)

Response: *Agreed and corrected.*

- Page 16, L31: in fact the wall heating should be more pronounced during the early morning and late afternoon that at 12:00, leading to potentially larger differences in the flow field at these times.

Response: *We agree. Also, the effect at 12:00 is most visible for the horizontal surfaces, including the streets (pavements). We removed this part of the sentence since it is not fully correct.*

- Page 17, L8: the second group includes.

Response: *Agreed and fixed.*

- Page 17, L29: are of good quality.

Response: *Agreed and fixed.*

- Page 17, L30: both urban configurations.

Response: *Agreed and fixed.*

- Page 18, L9: compared to those.

Response: *Agreed and added.*

- Page 18, L11: based on the above discussion.

Response: We *agree. We removed "Overall,".*

- Page 18, L13: Maybe more precise: within the urban canopy layer.

Response: *Agreed and replaced.*

- Page 18, L20: to include.

Response: *Agreed and fixed.*

- Page 21, L2: the results show.

Response: *Agreed and fixed.*

- Figure 4: must it not be "the LW irradiance is blue"?

Response: *Agreed and fixed.*

- Figure 10: are folded the same way.

Response: *Agreed and fixed.*

- Figure 27: "wind wind speed".

Response: *Agreed. The extra word “wind” is removed.*