

We want to thank the editor and the anonymous referee for their positive and constructive comments. Below, we provide our point-by-point reply.

Anonymous Referee #1

The authors have well taken into account the reviewers comments and I have only some minor remarks. The Line numbers refer the tracked changes version of the manuscript.

R: We are grateful for the reviewer's positive statements about the paper. We provide below our replies to each comment.

Line 12: You might specify which ensembles of RCM simulations (e.g. EURO-CORDEX); such that the sentence becomes more precise.

R: We added EURO-CORDEX and CMIP5/6 as examples of RCM and GCM ensembles.

Line 72: "shown" is used twice in the same sentence.

R: Second "shown" replaced with "demonstrated".

Line 103: "other approaches": this is not very precise, so please provide a bit more details on what has actually been done.

R: We agree with the reviewer, we provided a more detailed statement in Line 103: "Other approaches to tackle this problem have been suggested in the past, namely using dynamical downscaling to run climate simulations at the start and at the end of the century (e.g. Georgescu et al., 2014; Krayenhoff et al., 2018; Broadbent et al., 2020)."

L176: The order of references is wrong. It should be the oldest first.

R: Fixed.

L331: Must it not be "while also changing its sign"?

R: Thank you. Fixed.

Topical Editor

Please check if the comments below are relevant to provide more synthetic information to improve your manuscript readability.

1. L38-43:

- Could you replace Oke (1982) or add to more updated reference, Oke et al. (2017, Urban Climates, T. R. Oke, H. Mills, A. Christen, Cambridge Univ. Press)

- There are studies to relate long-term UHI to economic conditions and add them to this paragraph (e.g., Hong et al., 2019; Li et al., 2020; He et al., 2022).

Hong et al. (2019) Temporal dynamics of urban heat island correlated with the socio-economic development over the past half-century in Seoul, Korea, Environmental Pollution.

Li et al. (2020) Socioeconomic drivers of urban heat island effect: Empirical evidence from major Chinese cities, Sustainable Cities and Society

He et al. (2022) Localized synergies between heat waves and urban heat islands: Implications to human thermal comfort and urban heat management, Environmental Research

R: We thank the editor for providing these relevant references which were promptly added to the paragraph and to the list of references at the end of the manuscript.

2. L88-90: I expect that UCM considers vertical exchanges of energy and mass only, which may emphasize the importance of your study.

R: UCMs when run in offline mode neglect the feedbacks between the urban canopy layer and the air above (that is, the atmospheric forcing of the model). Technically, it does include some feedbacks, namely between the land surface and the urban canopy layer.

3. L 139: Could you also mention uncertainty of LST by building material emissivity?

R: We added it to the sentence in Line 139.

4. L174-176: I am quite sure if this sentence is in the relevant position when I consider the sentences before this one.

R: The sentence was moved to the Introduction section in Line 86.

5. Section 2.3: For comparison of other studies, I recommend that you provide RMSE in the manuscript.

R: Added a new figure for RMSE (equivalent to Figures 3 and 5 but for RMSE), which is the new Figure 6. The old Figures 6,7,8,9,10 are now Figures 7,8,9,10,11. RMSE was also included in Figures 7 and 10 (old Figures 6 and 9). The Results and Discussion section was updated to include RMSE in the text.

6. Figure 3:

- Can you reduce negative bias in the SFX-ROCK experiment by modifying thermal properties of rock covers in the experiment? This may provide some hints for the simple diagnostic values for UHI simulations.

R: It is likely that modifying the thermal properties of rock covers could change the errors. However, this would require calibration. Instead, here we are using the standard SFX-ROCK land cover, compared to using a more realistic representation of the urban cover using the SFX-TEB scheme, which also includes a more realistic representation of the surface thermal properties obtained from ECOCLIMAP database.

- Also, I wonder if you can discuss why SFX-TEB shows substantial positive bias of daytime LSTmax in JJA. I wonder how to assign anthropogenic heat emission in summer and winter.

R: The substantial positive bias of daytime LSTmax present in SFX-TEB in JJA might be explained by the model's lack of coupling with the atmosphere but it is difficult to disentangle this lack of coupling from other possible sources of error (e.g. misrepresentation of surface properties, observational uncertainty). There is certainly plenty of room for improvement in the modeling of urban physical processes, but this is beyond the scope of this study.

- I expect that UHI is dominant in nighttime temperature because of thermal properties of buildings but Fig 3 and 5 show that SFX-TEB does not give substantial improvement in nighttime. Could you provide any idea and implications on this?

R: There is not a substantial improvement in nighttime because the offline approach does not include land-atmosphere feedbacks. We mentioned this fact in the conclusions section (lines 482-484).

7. Figure 7: It is interesting that the SFX-TEB improves the UHI near sunrise and sunset substantially. Could you discuss this finding?

R: SURFEX overestimates in daytime and underestimates in nighttime (due to lack of land-atmosphere feedbacks). The sunset/sunrise improvement is likely due to SFX-TEB getting the timing of the cooling/warming correctly and the feedbacks being less impactful at those times of the day.

8. Figure 2 and 8: Can you add urban boundary described in Figure into these two figures?

R: We added the inner circle from Figure 1 that represents the urban boundary to Figures 2 and 9 (old Figure 8).