Specific comments

1. Lines 112: on the compound urban climate mitigation mechanisms, the following study provides a mathematical formalism that may worth considering:

Wang, Z.H. (2021). Compound environmental impact of urban mitigation strategies: Co-benefits, trade-offs, and unintended consequence. Sustainable Cities and Society, 75, 103284. https://doi.org/10.1016/j.scs.2021.103284

We will incorporate these relevant insights to enhance our manuscript. We will add the sentence:

Wang (2021) proposed a mathematical framework for unified evaluation of compound impacts emphasizing that compound urban climate mitigation should be evaluated in a comprehensive way.

2. Line 160-161: "However, the multilayer models solve the vertical profiles of the atmospheric conditions", the phrase "atmospheric conditions" is too general to describe the multilayer UCM, it is more precise to use "canopy-layer flows and momentum transport".

We will revise the 'atmospheric conditions' into a more detailed description of 'canopy-layer flows and momentum transport'.

We will the manuscript lines 160 – 161: *The single-layer models treat the urban canyon as a homogeneous area. However, the multilayer models solve the vertical profiles of the canopy-layer flows and momentum transport.*

3. Table 1: under SLUCM, the citation Wang et al., 2021 should be referring to

Wang, C., Wang, Z.H., & Ryu, Y.H. (2021). A single-layer urban canopy model with transmissive radiation exchange between trees and street canyons. Building and Environment, 191, 107593. https://doi.org/10.1016/j.buildenv.2021.107593

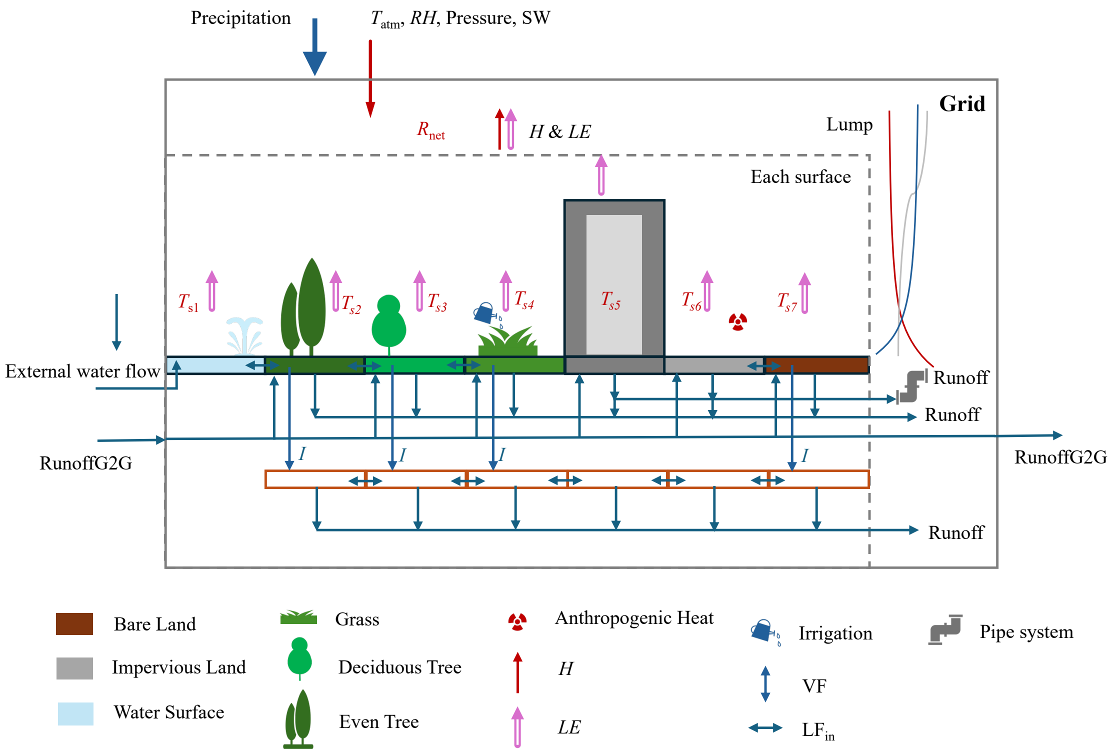
which is not included in the reference list.

We will revise the reference in Table 1 and add it to the reference list.

4. Figure 1: I wonder if it is necessary to separately indicate the surface temperature and net radiation for heterogeneous landuse. For by the same token, sensible (and latent) heat fluxes for these facets are also different and should also be separately indicated.

In addition, there is a downwelling R_{net} and 7 upwelling R_{nets}, while the net radiation from the urban canopy should be the combination of them, and none of the individual components can be called R_{net} I'd suggestion to keep the separate representation of surface temperatures as it is, but combine the radiation into a single R_{net} (or with a downwelling radiation as R_{down} and a upwelling component as R_{up}).

Indeed, the R_{net} should be the combination. Thank you very much for the suggestion; we will update Figure 1 as you suggested, please see below revised figure.



5. Lines 226-229, "The single-layer urban canopy model developed by Kusaka et al. (2001) (SLUCM) is very similar to TEB. The only differences are that the SLUCM in this version (Kusaka et al., 2001) includes the canyon orientation and diurnal change of solar azimuth angle, and the surface consists of several canyons with different orientations." This statement is incomplete. In fact, Kusaka's SLUCM, as implemented into WRF, contains a different parameterization scheme of radiation by discretizing the canyon facet and computing radiation on individual gridcells, whereas TEB uses the analytical formulae for in-canyon view factors. For simple rectangular canyons with only walls and roads (and short vegetation), Kusaka's radiation scheme is a setback to the analytical formulation, but it opens the possibility to include radiative exchange by roughness elements presented in street canyons such as trees/blocks/vehicles.

We double-checked Kusaka's SLUCM, ASLUCM and TEB, especially the radiation parameterization scheme, as you mentioned, and propose to revise the manuscript as follows:

Masson (2000) developed a single-layer urban canopy model called the Town Energy Budget (TEB) scheme. Similarly, Kusaka (2001) introduced the Single-Layer Urban Canopy Model, which is integrated into the Weather Research and Forecasting model (WRF-SLUCM). Unlike TEB, which uses analytical formulas for in-canyon view factors, WRF-SLUCM employs a distinct radiation parameterization scheme by discretizing canyon facets and calculating radiation for individual grid cells. Although Kusaka's scheme may be less efficient for simple rectangular canyons with walls, roads, and short vegetation, it has the advantage of accounting for radiative exchanges involving roughness elements such as trees, blocks, and vehicles within street canyons.

6. Table 3, I don't really understand how the temporal resolution of different ULSMs is determined. If the temporal resolution refers to the time intervals/steps used to solve the parameterization scheme, it varies widely depending on the discretizing (forward- or central-in-time finite difference) schemes, running platforms (offline or imbedded in regional climate models such as WRF), and applications. The time steps used to solve parameterization schemes can be as small as 1s (e.g. WRF-UCM for it used both spatial-temporal discretization for land-atmosphere interactions), or as large as 30 min. If the temporal resolution refers to the time scale for sampling the output, it is a rather arbitrary choice of the users. For instance, output of WRF-UCM is often sampled in hourly scale, like what is indicated in the table, but it can also be sampled at 3-hourly or 6-hrouly intervals for longterm (monthly to annual) simulations, but it can also be, in theory, sampled at 1s interval. My understanding is that the temporal resolution of all UCMs have no essential difference as their parameterization schemes represented by partial differential equations of land surface processes are all similar. The spatial scale for them does vary for SLUCM resolves the physical structure of the canyon, and building-resolving models has to resolve individual buildings, while slab models represent the aggregated urban landscapes.

In the manuscript, we tried to summarize the temporal resolution of the model outputs, as you said, at the hourly scale for WRF-UCM. Our review indicated that the analysis of model outputs for urban climate applications is typically conducted on a minute-to-hourly basis. However, we acknowledge your comment that the temporal resolution of UCMs should be determined by the needs of the users rather than the simulation capabilities of the model. It can be monthly or yearly, and theoretically, it can be seconds. Therefore, we modified the table and we will replace the previous table with below revised one. The temporal resolution is specifically for sampling frequency of the model output.

Table 3. Information of included models. The information is based on the literature listed in Table 1 and Table 2 and also on Salvadore et al. (2015). The column of Temporal Resolution is marked by *, indicating that the time scale is for sampling the model output.

Shortname	Type	Simulation Unit	Spatial Resolution	Temporal Resolution*
SUEWS (WRF-SUEWS)	Bulk (2-Tile)	Grid cell	100 m - 5 km	min - hr
VUCM (WRF-VUCM)	Canopy-Single layer	Grid cell	100 m - 5 km	min - hr
ASLUCM (WRF-SLUCM)	Canopy-Single layer	Grid cell	100 m - 5 km	min - hr
TEB (WRF-TEB)	Canopy-Single layer	Grid cell	100 m - 5 km	min - hr
TARGET	Canopy-Single layer	Grid cell	100 m - 1 km	min - hr
UT&C	Canopy-Single layer	Grid cell	100 m - 1 km	min - hr
VCWG	Canopy-Multi layer	Grid cell	100 m - 1 km	min - hr
BEP (WRF-BEP)	Canopy-Multi layer	Grid cell	100 m - 5 km	min - hr
VTUF-3D	3D Building resolved	Mesh cell	1 m - 10 m	min - hr
Solene-Microclimat model	3D Building resolved	Mesh cell	1 m - 10 m	min - hr
SWMM	1D Hydraulic	Sub-catchment	100 m -	min
Multi-Hydro model	1D Hydraulic-hydrological	Grid cell	100 m -	min
URBS	1D Hydraulic-hydrological	UHE	10 m - 1 km	min
WEP	2D Hydraulic-hydrological	Grid cell	100 m - 5 km	min - hr

We will also add the following description addressing this issue:

The temporal resolution refers to the time scale for sampling the model output. Although the analysis of the model output is a rather arbitrary choice for users, the table shows the general timescale at which the model output is analyzed. Theoretically, it can be monthly or yearly, but it can also be in seconds. The temporal resolution of the 2D ULSMs is above half an hour and can reach the minute level for the 3D ULSMs.

7. Table 5: SLUMC should be SLUCM (same typo in Tables 6 and 7). Also, I am concerned about the naming of the urban canopy models. The discussion of the single-layer urban canopy models in this paper is largely based TEB, Kusaka's UCM implemented in WRF, and the Arizona Single Layer Urban canopy Model (ASLUM, the name is used in Wang et al., 2021, Lipson et al., 2024, and Jongen et al., 2024). Yet TEB is separately discussed in this table, and SLUCM seemingly groups ASLUM and Kusaka's model. Given the fact that Kusaka's single-layer model is not further developed in a separate line, the representative SLUCM should be more properly named after ASLUM, as the latter is a coherent family of models developed by the same group of model developers in a continuous manner (Wang et al., 2013; Wang, 2014; Yang et al., 2015; Ryu et al., 2016; Wang et al., 2024).

We agree and will modify the references to SLUCM to ASLUM throughout the whole manuscript. We will double-check the typos and revise them.

In the revised manuscript, we will add a description in Section 3.2 "Urban canopy models", to distinguish between the Kusaka's SLUCM and ASLUM: "*ASLUM was developed following Kusaka's SLUCM and has been updated to the present (Wang et al., 2013)*".

8. Section 6: this part presents some thought-provoking questions that need to be pursued in future development of urban climate and urban environment modeling in depth. I would suggest the authors also include a brief discussion of the potential of AI and machine learning application in the field, given that these tools are increasingly adopted and some promising results generated from pioneering work in this field.

Your suggestion to include a discussion on the potential applications of AI and machine learning in this field is highly valuable. Although our review primarily focuses on process-based models, the benefits of AI techniques for further model development and their potential to influence the scientific direction are indeed worthy of discussion. We will incorporate this topic to enrich our manuscript and provide a more comprehensive overview of the future directions in this field.

In Section 6.4 "Collaboration within and across disciplines", we will add one paragraph to discuss how AI and ML can work with physics-based models, contributing to the simulation of urban hydrometeorology, and encourage its future application:

Building on the importance of interdisciplinary collaboration highlighted in our discussion, artificial intelligence (AI) and machine learning offer transformative potential for urban climate and environment modeling. These technologies can enhance predictive accuracy, identify complex patterns, and optimize model parameters, thereby complementing the collaborative efforts in atmospheric science, hydrology, and hydraulics. It has been shown that machine learning models and statistical models can work together with the physics-based models while being applied to different urban adaptation strategies under climate change (Li et al., 2022; Aliabadi et al., 2023). To study the urban heat, machine learning is applied for downscaling by generating high-resolution data from lower-resolution results from physics-based simulations, reducing temperature errors, and lowering computational costs (Wu et al., 2021b). Forecasting can benefit from AI and machine learning by working with numerical simulations and measurement data to enhance data accuracy and model performance for climate disasters (Luo et al., 2022). He et al. (2023) introduce a hybrid data assimilation and machine learning framework integrated into the WRF, which optimizes surface soil and vegetation conditions to improve regional climate simulations. To fully leverage these advancements, urban climatologists and hydrologists should also engage in discussions with scientists who specialize in AI applications. These interdisciplinary dialogues are crucial for integrating AI-driven insights into urban geoscience, aligning with our findings and recommendations on the necessity of interdisciplinary cooperation to address climate and natural disasters effectively.