Title: "Urban Weather Modeling using WRF: Linking Physical Assumptions, Code Implementation, and Observational Needs

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We thank the reviewer for this constructive and insightful review. We have prepared the following detailed author response narrative.

1. **Reviewer comment**: This manuscript describes and compares three different urban land-surface schemes in WRF, down to the specific code implementations and precise differences. This document is a rare comparison of the actual implementations instead of just comparing simulation outputs. The authors also go beyond a mere tech note and add significant, informed discussion of the schemes, suggesting observations that could help improve inconsistencies and shortcomings. This could be a good template for future scheme comparisons; in particular the use of exact symbol names from the code is an excellent idea. For these reasons, this paper should be published. I have some concerns about the manuscript I would like to see addressed before acceptance.

   (a) Eqn. 8: Is this supposed to just be applied to wall (B) and (G) but not either roof category? If so, how is the heat flux computed for the two kinds of roofs? Also, do we expect more than very minimal wall-surface to be represented at resolutions that mesoscale models are run at?
   Author response: The authors thank the reviewer for carefully examining the formulation presented in the article. Equation 8 indeed only applies to the wall and ground but not the roof categories. Equation S1 presents the equivalent equation for the roof surfaces. Since the two equations have a lot in common, we explain how they related on line 137 "In the SLUCM a distinction is made during the sensible heat flux calculation for each surface (H) to account for the fact that the roof surfaces are closer to the first atmospheric level, than building walls and groundThis distinction leads to using different air temperature and wind information when calculating heat flux for the roof (R) and green roof (GR) surfaces (sup eq. 1) compared to the wall (B) and ground (G) surfaces (eq. 8). Where canopy wind speed UC is used for the building walls and ground surfaces, wind speed at the lowest atmospheric level, denoted as UA, is used for the roof surfaces. Similarly, where the canopy temperature TCP is used for building walls and ground calculations, the air temperature at the lowest atmospheric"
   Manuscript revision: Lines 77-81 (revised version): "A single grid cell in a mesoscale model typically contains numerous buildings and streets that vary in physical characteristics such as height, width, and thermal properties. However, representing these heterogeneous features with a single, uniform type of building or street oversimplifies the complexity of real urban morphology. Therefore, a more realistic depiction of urban areas requires advanced urban canopy models that incorporate multiple types of buildings and their distinct thermal attributes."

   (b) Section 3.2: Is everything on lines 237–272 about SLUCM, after which BEP in MLUCM is discussed?
   Author response: The reviewer has correctly noted this point. The content between lines 237 and 272 pertains to discussions on SLUCM, while BEP is addressed in the following paragraphs.

   (c) Also Section 3.2, lines 268–272: that the minimum moisture availability (BET) has such a large effect on urban energy balance is an interesting finding, although it is disturbing that the default value during rain events leads to instabilities. Is this because the default simply allows for too much latent heat flux, causing a runaway feedback, or is there a numerical cause for this instability?
   Author response: The authors thank the reviewer for emphasizing the importance of the BET. However, the authors did not have the opportunity to examine the root cause in detail, as this was only an informal discussion on the WRF & MAPS support forum and not part of a published study. Even so, it is concerning that this parameter can lead to unrealistic results, highlighting the need to validate its limits—and those of similar parameters—through field observations.

   (d) Section 3.2, lines 295–300: it is a bit shocking to know that the poor state of canopy resistance measurements has been known for 20 years now. I am hopeful that this paper may spur some action.

   (e) Eqn. 33: Are dg and dgr prognostic variables?
   Author response: The authors sincerely appreciate the reviewer's effort in examining the characteristics of the variables. The variables dg and dgr are prognostic in nature.

Manuscript revision: Line 285 (revised version): ", a prognostic variable,"

(f) Eqns. 37 and 38: Why two separate values of SG? One shaded and one sunlit?
Author response: Thank you for the question. The use of two separate values of ground heat storage flux (SG)—one for shaded and one for sunlit conditions—is likely a design choice in the code implementation rather than a physical necessity. Both terms could have been combined since one does not depend on the other.

(g) The figures 1–4 showing the differences in the very complex radiative transfer between SLUCM and BEP in MLUCM is quite useful. Is such a complex scheme really worth the additional computational cost?
Author response: We appreciate the reviewer's thoughtful question. Our intuition is that the added complexity—and associated computational cost—of the BEP and MLUCM radiative transfer schemes is more justified in urban environments characterized by a mix of high-rise and low-rise buildings, where 3D radiative interactions are more pronounced. However, the benefits of using a more complex scheme—or the trade-offs of relying on a simpler one—should ideally be evaluated on a case-by-case basis. We believe this warrants systematic assessment when configuring simulations for a new city, particularly when balancing model accuracy with computational efficiency. We have added a statement to this effect in the revised manuscript.
Manuscript revision: Lines 458-462 (revised version): "The discussions on radiative exchange between surfaces in SLUCM and BEP clearly demonstrate that the added complexity of BEP and MLUCM in modeling radiative transfer may offer greater benefits in urban environments with mixed building heights and complex geometries. However, the trade-off between model realism and computational cost should be carefully considered when setting up simulations for a specific city. A systematic evaluation of model performance versus complexity can help guide the choice of urban scheme."

(h) Section 5, lines 498–502: It is suggested that MOST is insufficient. What may be used to go beyond MOST?
Author response: At present, we do not have a specific alternative to Monin-Obukhov Similarity Theory (MOST) to recommend for mesoscale models that must parameterize surface fluxes. Ideally, the community should move towards employing high-resolution models that explicitly resolve urban turbulence and surface heterogeneity. However, we recognize that this approach comes with significant computational demands and greater requirements for detailed boundary conditions.

(i) Section A1, line 545: "even minor implementation issues can meaningfully influence model output" is an excellent point describing one of the biggest challenges of model development, and of engineering in general.

Line 144: "denote" should be "denotes".
Manuscript revision - Line 148 (revised version): **denote → denotes**
Lines 240–242: Some symbols did not get correctly formatted as LaTeX Math Mode.
Manuscript revision - Lines 244-246 (revised version): (\$B\$, \$G\$, \$R\$, \$UC\$) → (B, G, R, UC).
Line 272: Missing bibliography reference
Manuscript revision - Line 272 (revised version): ", UCAR WRF Support Forum (2024),"
Line 275: "IN" → "In".
Manuscript revision - Line 279 (revised version): **IN → In**.
Line 327: Is this supposed to be 2.5 or $2^5 = 32$?
Manuscript revision - Line 339 (revised version): 2**-**5
Line 379: Missing equation reference.
Manuscript revision: Line 392 (revised version): **urban vertical layers as described in Equation ??. → urban vertical layers.**