Review Report for Manuscript: A conservative immersed boundary method for the multi-physics urban large-eddy simulation model uDALES v2.0

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1 General

The manuscript titled "A conservative immersed boundary method for the multi-physics urban large-eddy simulation model uDALES v2.0" presents advancements in the uDALES framework, particularly focusing on the implementation of a conservative immersed boundary method (IBM) for urban surface representation. This method aims to address the challenges associated with complex urban geometries in microscale urban airflow simulations. While the paper demonstrates improvements over the previous version of uDALES and provides insights into the capabilities of the new method, several key issues need to be addressed before the manuscript can be considered for publication.

2 Major Issues

- **Radiation Interaction and Reflections**: One major issue concerns the clarity of the radiation interaction process and reflections in the manuscript. The explanation of how the new method of surface representation improves reflections is not adequately presented. While the authors briefly mention view factors, further details are needed to understand the specific improvements achieved with the new method. Additionally, the validation simulations do not adequately reflect the impact of the improved surface representation on radiation interactions. I believe further clarification and demonstration is needed.
- **Simplicity of Test Cases**: Another major concern is the simplicity of the test cases used for validation, which may not fully capture the complexity of urban environments. The validation simulations should consider a wider range of scenarios to assess the robustness and applicability of the new method in diverse urban settings. Incorporating more realistic urban configurations and environmental conditions would strengthen the validity and relevance of the findings. Otherwise, justification is missing here.
- **Representation of Resolved Vegetation**: The manuscript lacks sufficient detail regarding the representation of resolved vegetation in the simulations. Given the importance of vegetation in urban microclimate simulations, particularly in

influencing surface energy balances and pollutant dispersion, it is essential to provide a comprehensive description of how vegetation is incorporated into the model and validated in the simulations. Including relevant references and discussing the implications of vegetation representation would enhance the completeness of the manuscript.

- **Increased Computational Requirement**: The introduction of the new triangular surface representation may significantly increase the number of surfaces compared to traditional rectangular surfaces. The potential impact of this increase on the performance and computational requirements of the model should be clarified. Authors are encouraged to discuss any potential implications for computational efficiency and scalability.

- **Accuracy of Numerical Solution**: The scheme now resembles somewhat an unstructured grid, which may raise concerns about the accuracy of the numerical solution due to increased numerical errors. Authors should address whether this change affects the accuracy of the solution and discuss any measures taken to mitigate potential errors (if any). The discussion should compare the accuracy with the traditional unstructured gird given here: `https://doi.org/10.1016/j.buildenv.2008.11.010`.

3 Minor Issues

- **Introduction Citations**: The introduction section lacks citations to support the background information provided. For example, lines 28-29 and lines 35-36 may benefit from adding some references, such as `https://doi.org/10.1016/j.enbuild.2023.113324`, which exemplify the application of micorscale urban climate models in realistic urban environments. Also the radiation model of PALM in line 54 (`https://doi.org/10.5194/gmd-14-3095-2021` and `https://doi.org/10.5194/gmd-15-145-2022`)

- **Additional Models in Introduction**: Lines 37-39 should include references to other relevant models such as MITRAS, MISKAM, etc., to provide a comprehensive overview of existing approaches in the field.

- **Temperature Scale in Figure Legend**: The temperature scale in the legend of figure 1 has a minimum and maximum of 300K. Additionally, the caption of the figure should be more informative to provide clear context and interpretation of the results.

- **Relevance of Certain Text**: Lines 74 - 77 may not be necessary and could be considered for removal if they do not contribute to the manuscript.

- **Organization of Content**: Line 153 should be moved to the relevant subsection for better organization and clarity.

- **Confined with ARCHER2**: Lines 158-160 suggest a confinement to ARCHER2, which may limit the generalizability of the findings. Authors should clarify whether the method is applicable to other computing platforms and address any potential limitations in this regard.

- **Figure 14**: The presence of incoming longwave radiation in Figure 14 should be clearly indicated or discussed in the caption to provide a comprehensive understanding of the depicted variables.

4 General Opinion

Overall, the manuscript presents valuable contributions to the field of urban microscale airflow simulation, particularly through the implementation of the conservative immersed boundary method in uDALES v2.0. Despite the major issues identified, the study demonstrates promising advancements in addressing the challenges associated with complex urban geometries. Addressing the identified issues, particularly regarding radiation interactions, test case complexity, and vegetation representation, will further strengthen the manuscript and enhance its impact in the field.