Review - MLUCM BEP+BEM: An offline one-dimensional Multi-Layer Urban Canopy Model based on the BEP+BEM scheme

Summary: This manuscript, entitled MLUCM BEP+BEM: An offline one-dimensional Multi-Layer Urban Canopy Model based on the BEP+BEM scheme" by G. Pappaccogli et al., describes the performance of a one dimensional multilayer urban canopy model (MLUCM) BEP+BEM. The comparison uses a standard dataset used for benchmarking from Melbourne Australia, and the model is forced by common weather and climate outputs (downwelling shortwave and longwave radiation, air temperature, specific humidity, wind speed, pressure, and precipitation). The model outputs of upwelling shortwave and longwave radiation, sensible and latent heat, and momentum flux are compared against observations. Three separate changes are made to show off MLUCM. The first uses site-specific observations of important urban fractions and prescribed values from local climate zone 6 (baseline). A second experiment adds in 6 more parameters, while the last simulation uses an additional building height distribution factor on top of the extra parameters.

Results show that this model is good at representing upwelling shortwave and longwave radiation, as well as the momentum flux due to the highly technical treatment of these factors. The performance of the other fluxes, sensible and latent, are lacking in the same skill, and ground heat flux was not mentioned at all. I agree that this article is worth publishing, but there are clarifications and extra work needed to ensure that a more complete picture is given to potential users of this code base. Specific attention should be paid to the "why" behind insensitivity to the sensible heat fluxes to different parameters and the lack of skill in the latent heat flux values. Specifically, I suggest:

Major points (in order of text, not in order of importance):

1. Is it a good assumption to not let longwave radiation interact with the tree canopy processes? Longwave radiation should be absorbed, transmitted, and emitted from the tree canopy like all other structures, which would then affect the radiative temperature and therefore heat flux partitioning. Please clarify what you mean by "The canopy interacts only with short-wave radiation and does not affect long-wave radiation components." on line 187.
2. Why use an empirical formulation for the partitioning of heat fluxes dependent on the shortwave radiation? Do street trees not have their own soil moisture stores that are similar to the street canyon gardens? Not taking into account the changes in soil moisture induced by urban trees, and the reduction in latent heat and subsequent

changes to sensible and ground heat fluxes, could be biasing the results of this study (e.g. a reason why there are such large discrepancies in the latent heat results).

3. Do you believe that the LCZ6 parameters you chose are representative for this space? Did you check the albedo and emissivity against remotely sensed averages? To my knowledge, LCZ give a range of values to select from, but these are likely to change given the age and type of architecture chosen for the study region.
4. Upon reading the street canyon gardens section, I think that clarification is needed to discuss whether street trees are treated similarly (e.g. using ecohydrologic principals) or not.
5. I think that a more detailed investigation of the "why" behind sensible and latent differences in the single layer BEP BEM model is needed. For instance, why is the baseline doing better in the sensible heat flux compared to the more detailed versions of the model presented? Is there a lack of sensitivity/too much sensitivity to the parameters that were introduced? For the latent heat flux, it is tricky to tell what is going on without a better explanation of how green areas are represented. Is there soil moisture/ hydrology being simulated? Or is this the ratio that was mentioned in the methods section? Examining the code shows that partitioning between sensible and latent heat fluxes for trees, which would be the major contributor to the latent heat signal, is using this ratio. More justification is needed on why this is appropriate given the biases that it introduces, given that urban trees do increase latent heat fluxes to be higher than those shown (even in modeling experiments, like related work with BEP-Tree (https://doi.org/10.1016/j.uclim.2020.100590) or tiling approaches in Noah-MP HUE that represent ecohydrology (**https://doi.org/10.1029/2023WR035511**)).
6. Authors could give a more detailed breakdown of what they hypothesize is going wrong than "whose cause deserves further investigations, are present for latent heat flux (Qle)." As stated on line 414.
7. What is going on with the ground heat flux? I am assuming there are no measurements, but do the results from this flux look believable? I would think that because of the errors in Qh and Qle, Qg would be also too high, and thus could cause a warming feedback when introduced into weather or climate models like suggested in the discussion.
8. The final point of this paper, "Further research includes experiments forcing the MLUCM BEP+BEM model with the ERA5 reanalysis to assess its sensitivity to various input parameters, including urban morphology and vegetation characteristics. Moreover, the model will be forced with climate projections to investigate the impact of climate change on the different urban processes, such as overheating,

building energy demands, outdoor thermal comfort, and the efficacy of adaptation strategies, including urban greening, green and cool roofs, photovoltaic panels and hybrid sustainable infrastructure." is a lofty goal, and I would agree that this model is able to look at urban morphology pretty neatly. The issue is coming from the vegetation characteristics, urban greening, green and cool roofs, and the interactions with urban comfort and other applications. As of right now, the latent heat flux and sensible heat fluxes are wrong, which would then cause these to be erroneous. This model is on the right track, but there needs to be more justification/investigation/discussion on how we could use this model to look at urban climate adaptation with the errors that are present within the model right now.

9. When investigating the model code, the code is clean but there are some missed opportunities to give an indication of what each of the subroutines are doing. Consider adding those so that folks who want to add/modify this code base will know what is going on in each routine and call to the routine!

Minor points:

1. Line 59: missing a space between "1 Dimensional"