GMD-2019-220 Review

Realistic representation of urban vegetation is an important step to improving model capabilities and performance. In this paper, a vegetated urban canopy model incorporating street trees (BEP-Tree) is coupled with a mesoscale model (COSMO). The authors briefly describe the relevant parts of the models and their combination, before evaluating the combined model against a range of observations. The work is well-presented, with a clear structure and, mostly, an appropriate level of detail (although in some places more discussion would be beneficial). The inclusion of street trees within the model is shown to make generally small improvements to the meteorology but substantial improvements to the sensible and latent heat fluxes. The coupled model will be useful for applications concerning urban greening as well as for more general studies which will benefit from better representation of vegetation processes.

The paper is very well-presented overall. There are a few consistency issues which need to be addressed and a little more explanation would be beneficial in parts. However, I recommend this publication following minor revisions.

Main points

- P8 L15: The lack of interaction with soil moisture seems to be the major weakness in this study. More discussion would be beneficial. Why was the decision made not to implement this interaction? Can the authors comment on the effect of this decision? How realistic is it to assume transpiration in urban areas is never limited by soil moisture (I would think not very realistic)?
- P10 L6: It is not clear how T_g relates to T_{nat} or T_s relates to T_{urb}
- P11 L5: Provide some justification for the statement about Basel's 'abundant green infrastructures' as the statistics and Fig 3b do not suggest a particularly vegetated city.
- P11 L16: Can the authors add whether any spurious structures occurred (as in other studies, e.g. Salamanca et al. 2012) given the small horizontal grid spacing used is in the 'grey zone'?
  Salamanca F, Martilli A, Yague C (2012) A numerical study of the urban heat island over Madrid during the DESIREX (2008) field campaign with WRF and an evaluation of simple mitigation strategies, IJC 32: 2372–2386 DOI: 10.1002/joc.3398
- P12 Fig 3: Station WEIL does not seem to be used anywhere in the manuscript – delete from the map
- P13 L3-4: Two sentences providing a general description of the imperviousness dataset and the buildings dataset would be helpful (i.e. are these fractions of impervious surface cover or degree of imperviousness; is it building height or building material or building use; at what resolution?)
- P15 Table 3: Latent heat flux seems to be denoted Q_L here and Q_E later in the manuscript – make consistent in all text, tables and figures. Fluxes also appear in the row for BLER – presumably this is incorrect?
- P15 L21-22: 'net' → 'four-component' as the CNR4 measures all four radiation components individually. Also, the radiation measurements are mentioned here but not used in the evaluation (e.g. in Fig 5). Why not? Can the authors comment on the results for the radiation components for STD and LA0 runs?
- P16 L4: Aren't there only five surface stations (depending on whether the WEIL data should be included or not)? Can the authors clarify here why no results from WEIL have been included?
- P17 L5: Here the emissivity values for urban surfaces are given as 0.95-0.97 but in Table 2 much lower values of 0.85, 0.9 and 0.95 are given, which seems to introduce an inconsistency. How would an emissivity of 0.85 affect the uncertainty estimation in L7?

- P17 L15-17: Define f_{dir} here as it does not seem to be defined in the main text
- P17 Fig 5 caption: The letters referring to the various panels needs correcting here and in the main text.
- P17 Fig 5 caption and in other captions: Personally I find it quite confusing to keep reading about the 5 days that were discarded for spin-up. Why not define a simulation period and a study period/analysis period (27 June-9 July) in Section 3.1, and then refer to this study period in the figure and table captions? Repetitions between captions could also be reduced.
- P19 Table 4 caption: Some inconsistency with the symbol for temperature that needs to be fixed (this was T previously, and is now T_{air})
- P19 L6: Suggest changing 'a small increase' to 'a very small increase' and presumably 'relative humidity' should be 'specific humidity' seeing as the units given are g kg^{-1}
- P19 L10: The wind speed overestimation occurs often: suggest changing 'a few days' to 'most days'
- P19 L9-12: The modelled wind speed is large, often exceeding 5 m s^{-1}. This seems quite large for a thermally driven circulation between city and surroundings. Perhaps the prescribed roughness lengths could also be a relevant factor. Did the authors consider this and could they comment on the impact of uncertainty in the prescribed roughness lengths on the evaluation results?
- P20 L21: 'may be related to exposure of the sensor to local influences' – please explain
- P21 Fig 6: Why are no results for BLER plotted here? This would help the reader to interpret Fig 7.
- P21 L4-7: A little deeper discussion would be helpful here. The performance of the model seems to go in the wrong direction in terms of comparison against the observations but this is because of the dominating effect of the temperature bias. However, the newly-incorporated processes seem to cause a change in the expected direction. This cautions against tuning models to match observations
- P22 L10-12: This two-sentence paragraph should be extended to include more discussion (with references from the literature) about the uncertainties of satellite-derived LST, particularly in urban areas. In Fig 8, do you trust the spatial patterns seen in the satellite observations? Crawford et al- (2018) discuss some of the biases affecting LST measurements in urban areas and how these vary spatially.
  Crawford B, Grimmond CSB, Gabey A, Marconcini M, Ward HC, Kent CW (2018) Variability of urban surface temperatures and implications for aerodynamic energy exchange in unstable conditions, QJRMS 144: 1719–1741 DOI: 10.1002/qj.3325
- P26 L3-4: Can the authors explain the finding that both increasing and decreasing leaf area density leads to a reduction in night-time temperature?

Minor points and suggestions for improving language and readability

- P2 L7: interactions concerning moisture should also be listed here
- P2 L11: 'heat interactions' is probably not the right term here, suggest changing to 'latent heat' or 'evaporation'
- P2 L12: 'excerpts' → 'extracts'
- P3 L4: 'Several… …fabrics' – this sentence is redundant given the previous and following sentences so can be deleted
- P3 L7: 'regarded' → 'concerns'
- P3 L9: 'regards' → 'concerns'
- P3 L11-12 and throughout: I would use the singular, i.e. 'street tree datasets' instead of 'street trees datasets'; 'street tree characteristics' instead of 'street trees characteristics' (otherwise you probably need an apostrophe)

- P3 L16: Suggest deleting 'in the presence of street trees'
- P3 L26: Suggest deleting 'the modelling' and adding to the end of this sentence 'by more realistic representation of the surface and its interactions', or similar
- P4 L4: 'garden' → 'gardens'
- P4 L6-8: There is no mention of Section 4 here which seems odd
- P4 L12, L24: It is not clear that '(COSMO)' is a reference. You could delete it from L12 and perhaps provide a year or give the URL in L24 to avoid confusion.
- P4 L20-22: The items in this list are not strictly all processes, suggest rephrasing.
- P5 Fig1 caption: 'the Sections' → 'Sections'
- P5 L6: Delete 'top of'
- P6 L4: Delete the second instance of 'i' as it seems as though 'the ray i' is defined twice
- P6 L25: Seems strange to define the density here before S_q
- P7 L3: 'latter' → 'canyon geometry inputs' and 'includes' → 'include'
- P7 L16: 'a measurement site'→ 'measurements'
- P7 L23-5: This sentence disrupts the flow here. Suggest deleting or making this the first sentence of Section 2.3.
- P7 L26: Would 'proportions' be better than 'configurations' here? – the model does not account for the arrangement of the surfaces or whether there is one larger urban surface or many smaller urban surfaces with the same total area
- P8 Fig 2 caption: 'Rose' → 'Orange'. Also most of these are quantities not 'operations' – suggest rephrasing
- P8 L1: Delete 'street canyon' (as sky is not really part of the street canyon)
- P10 L4: Start this sentence with 'Following Schubert…'
- P10 L13: 'UPC' → 'UCP'
- P10 L14: The reference to Fig 2 would be more helpful in L16
- P11 L1-8: Change the numbers in this section so that commas rather than apostrophes separate the digits (e.g. '830'000' → '830,000')
- P12 Fig 3 caption: State what the dashed line represents in the figure caption
- P13 L1: 'in the centre-south and centre-west' → 'south and west of the centre'
- P14 Fig 4 caption: 'urban tile' is probably be better than 'urban canopy' as the latter could be interpreted as trees above buildings
- P14 Fig4 caption: Change to 'Further details about the variables are given in Table A1'
- P14 Table 2 and in other tables too: Use a consistent number of decimal places, e.g. 0.10 0.10 and 0.15 for albedo; 0.85, 0.90 and 0.95 for emissivity
- P15 L4: Change to 'vehicles and seasonal'
- P15 L7: It would be more useful to explicitly state the period over which the average was calculated
- P15 L13 and elsewhere: Should this be 'MCR-Lab' not 'MRC-Lab'?
- P15 L14: 'building' → 'buildings'
- P15 L17: ', but' → ' and'
- P15 L17: 'estimated to' → 'estimated at' or 'estimated to be'
- P15 L22: You could add 'in general' to make it clear that these considerable uncertainties are not only for the Basel dataset
- P16 L7: 'placed' → 'located'
- P16 L8: 'then' → 'than'
- P16 L8-9: 'in the area' – in which area? The urban canopy layer is extremely spatially variable so there would be considerable temperature variation expected throughout any 'area'
- P16 L19: Delete 'as well'
- P16 L21: Change to 'Given the vegetated environment and distance from the city centre,' to avoid misinterpretation
- P16 L21-22: Change to 'as a rural reference'
- P17 L30: Delete 'will'

- P17 Fig5: Delete the unhelpful minor tick marks on the right-hand plots.
- P19 Table 4 caption: Change '(see Table 1… set-up)' to '(LA0)'
- P19 Table4 caption: You could point out that the units only apply to RMSE and MBE, not r^2
- P19 L11: Change 'and' to 'or'
- P19 L15: Change 'of' to 'by'
- P20 L3: Shouldn't '0.06' be '0.04'?
- P20 L6: Suggest deleting 'slight' as the overestimation is appreciable. Also add that r^2 gets worse here.
- P20 L16: Delete '2-m air temperature'
- P20 L17: Delete 'will'
- P20 L30-31: Avoid this two-sentence paragraph by moving 'The statistical scores…only.' to the end of the previous paragraph and 'The comparison between… Fig. 7.' to the start of the following paragraph.
- P21 L1: 'lower' → 'lesser'
- P21 L14 'outskirt' → 'outskirts'
- P22 L3: Change 'only quite' to 'quite'
- P22 L3: Change to '…STD and LAO are seen, with STD…'
- P23 L2: 'ST' → 'surface temperature'
- P23 L6: Why is 2-m air temperature now denoted T_{air} and not T_{2m} as before?
- P24 Table 7: Units of surface temperature are missing
- P26 Fig9 caption: Change 'S' to 'S_φ' in line with Eq 15
- P26 L13-4: Join this first sentence with the following paragraph
- P27 L3: Change to 'of the clumping index'
- P27 L6-7: Change to 'the temporal changes of Ω with solar zenith angle'
- P27 L24: Change to 'values of the material properties for roof, wall and street elements were used'
- P27 L28: Should read 'WUDAPT'
- P28 L15: Change to: 'generally well, although its magnitude'
- P28 L16: Change 'it' to 'this difference'
- P28 L18-21: Again some mention of uncertainties in LST would be helpful here
- P28 L23: Change to 'found only at some'
- P29 L7: Close bracket missing after the email address
- P29 L9: Change to 'as a standalone'
- P30 L12-3: Define A_F
- P31 L1: 'heigh' → 'height'
- P32 L24 and L32: Check reference formatting