Reply to reviewer's comments

Typographical convention:

Black -> reviewer's comment

Blue -> author's comment

Red -> modification to the manuscript

Underlined -> text added to the original version

~~Strikethrough~~ -> text removed from the original version

The line numbers refer to the original version of the manuscript.

Reviewer 1 (RC1)

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.

We are happy that the reviewer appreciated the paper. We included further discussion and fixed the inconsistencies.

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)?

We added a discussion on the lack of interaction with soil moisture.

P8 L15 "Although moisture exchange between street trees and the atmosphere is implemented, street trees do not interact with soil moisture content as represented by COSMO's land surface scheme. In other words, a mechanistic interaction between soil moisture and the transpiration of street trees is

not included, assuming that the transpiration is never limited by soil water availability. A careful representation of soil moisture in the urban tiles would have required the development of a new urban hydrology scheme, which was beyond the scope of the study. The missing interaction with soil moisture may reduce the model ability to represent variations in transpiration during periods with large changes in soil moisture (Konarska et al., 2016; Asawa et al., 2017). Nevertheless, street trees are less sensitive to variations in soil moisture than short vegetation, thanks to their deeper root system (Chen et al., 2011; Asawa et al., 2017)."

Additionally, the section "Future studies" is extended accordingly.

P26, L18 "In order to improve the representation of the transpiration from street trees and therefore the modelling of the associated latent heat fluxes, a mechanistic stomata model (e.g. Damour et al., 2010) should be implemented. Furthermore, to properly represent soil water availability during extended drought periods, an urban hydrology module should be developed and coupled to COSMO-BEP-Tree (e.g. Järvi et al., 2011, Yang et al., 2015, Stavropulos-Laffaille et al., 2018)."

Additional references:

Chen, Lixin, et al. "Biophysical control of whole tree transpiration under an urban environment in Northern China." *Journal of Hydrology* 402.3-4 (2011): 388-400. https://doi.org/10.1016/j.jhydrol.2011.03.034

Asawa, Takashi, Tomoki Kiyono, and Akira Hoyano. "Continuous measurement of whole-tree water balance for studying urban tree transpiration." *Hydrological Processes* 31.17 (2017): 3056-3068. https://doi.org/10.1002/hyp.11244

Järvi, Leena, C. S. B. Grimmond, and Andreas Christen. "The surface urban energy and water balance scheme (SUEWS): Evaluation in Los Angeles and Vancouver." *Journal of hydrology* 411.3-4 (2011): 219-237. https://doi.org/10.1016/j.jhydrol.2011.10.001

Yang, Jiachuan, et al. "Enhancing hydrologic modelling in the coupled weather research and forecasting–urban modelling system." *Boundary-Layer Meteorology* 155.1 (2015): 87-109. https://doi.org/10.1007/s10546-014-9991-6

Stavropulos-Laffaille, Xenia, et al. "Improvements to the hydrological processes of the Town Energy Balance model (TEB-Veg, SURFEX v7. 3) for urban modelling and impact assessment." Geoscientific Model Development 11.10 (2018): 4175-4194. https://doi.org/10.5194/gmd-11-4175-2018

Konarska, Janina et al. "Transpiration of urban trees and its cooling effect in a high latitude city." International journal of biometeorology 60 (2016): 159–172. https://doi.org/10.1007/s00484-015-1014-x

- P10 L6: It is not clear how T_g relates to T_{nat} or T_s relates to T_{urb}

We apologize that there was a typo in the second part of the equation. f_{nat} should always go with T_g and f_{urb} with T_s . Additionally, the definition of T_s was not consistent with its use later in the manuscript (where it is referred to as T_{str}).

We corrected the equation and the following explanation.

P10, L6 "$T_{2m} = (f_{nat}\ T_g + f_{urb}$ ~~T_s~~ $T_{str}) + r\ (T_1 - (f_{nat}$ ~~T_s~~ $T_g + f_{urb}$ ~~T_g~~ $T_{str}))$,

where T_g is the surface temperature of the natural tile, T_{str} is the street surface temperature~~ of the urban tile~~, … "

- 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.

This statement was based on information provided by the city offices. We reviewed the scientific literature but did not find any studies that substantiate our statement. Therefore, we rephrased the sentence and removed the statement about 'abundant green infrastructures'.

In order to allow a comparison with other studies, we calculated the average canopy cover from street trees and added an according sentence to the manuscript. A figure with the variability of the canopy cover from street trees in the different districts is added to the Supplement (Figure R1).

P11, L3: "The inner city (Basel-Stadt) includes ~~is characterised by an abundance of green areas with~~ more than 24'000 urban trees and 275 hectares of public vegetated surfaces distributed over a total area of the city centre of approx. 2'385 hectares (Stadtgaertnerei Kantons Basel-Stadt). The average canopy cover from street trees is about 20% when considering the entire urban area, but it varies from 6 to 31% in the different districts (see Supplement). The city of Basel is ~~not only~~ an interesting target for ~~its abundant green infrastructures, but also for~~ the availability of extensive observational data sets for model evaluation, which had been used in numerous previous urban climate studies (e.g. Rotach et al., 2005; Parlow et al., 2014)."

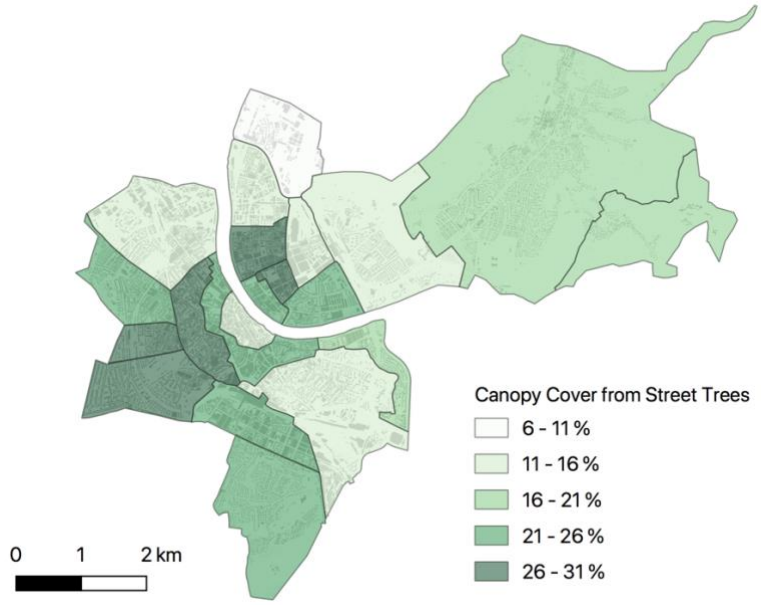

Figure R1 - Canopy cover from street trees in the administrative districts of Basel-Stadt. The building geometries are shown in the background.

- 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

Clear spurious structures were not detected in the simulations.

Nevertheless, a sentence regarding the use of the model in the so-called grey-zone is added in the section "future studies".

P27, L28: "It has to be noted that the model resolution in this study falls within the so-called "grey zone" or "terra incognita" (Wyngaard, 2004) of meso-scale atmospheric modelling, a condition where the horizontal grid spacing and hence the scale of the spatial filter used on the equations of motion are of the same order as the scale of the energy- and flux-containing turbulence. This condition may produce a misrepresentation in the turbulence and wind speed patterns (Efstathiou et al., 2015). High-resolution urban climate studies reported the formation of horizontal convective rolls which have an unclear counterpart in the real atmosphere (Salamanca et al., 2012; Gutiérrez et al., 2015). Although such issues were not visible in this application, these aspects need to be considered in future studies, for example by exploring the performance of new scale-aware turbulence schemes (e.g. Junshi et al., 2015, Shin et al., 2015) or large-eddy-simulation schemes as recently developed for the COSMO model (Panosetti et al., 2016)."

Additional references:

Efstathiou, G. A., and Robert J. Beare. "Quantifying and improving sub-grid diffusion in the boundary-layer grey zone." *Quarterly Journal of the Royal Meteorological Society* 141.693 (2015): 3006-3017. https://doi.org/10.1002/qj.2585

Gutiérrez, Estatio, et al. "Simulations of a heat-wave event in New York City using a multilayer urban parameterization." *Journal of Applied Meteorology and Climatology* 54.2 (2015): 283-301. https://doi.org/10.1175/JAMC-D-14-0028.1

Shin, Hyeyum Hailey, and Song-You Hong. "Representation of the subgrid-scale turbulent transport in convective boundary layers at gray-zone resolutions." *Monthly Weather Review* 143.1 (2015): 250-271. https://doi.org/10.1175/MWR-D-14-00116.1

Ito, Junshi, et al. "An extension of the Mellor–Yamada model to the terra incognita zone for dry convective mixed layers in the free convection regime." *Boundary-layer meteorology* 157.1 (2015): 23-43. https://doi.org/10.1007/s10546-015-0045-5

Panosetti, Davide, et al. "Idealized large-eddy and convection-resolving simulations of moist convection over mountainous terrain." *Journal of the Atmospheric Sciences* 73.10 (2016): 4021-4041. https://doi.org/10.1175/JAS-D-15-0341.1

Salamanca, Francisco, Alberto Martilli, and Carlos Yagüe. "A numerical study of the Urban Heat Island over Madrid during the DESIREX (2008) campaign with WRF and an evaluation of simple mitigation strategies." International Journal of Climatology 32.15 (2012): 2372-2386. https://doi.org/10.1002/joc.3398

Wyngaard, John C. "Toward numerical modeling in the "Terra Incognita"." *Journal of the atmospheric sciences* 61.14 (2004): 1816-1826. https://doi.org/10.1175/1520-0469(2004)061<1816:TNMITT>2.0.CO;2

- P12 Fig 3: Station WEIL does not seem to be used anywhere in the manuscript – delete from the map

The station WEIL is removed from Figure 3.

- 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?)

We added two sentences describing the imperviousness dataset and the building dataset.

P13, L5: "The urban canopy parameters were derived with UCPgenerator from the following input datasets: (a) imperviousness from EEA (2015), (b) 3D buildings from Federal Office of Topography (2007) and (c) lidar-based tree canopy height (see data availability section). The imperviousness dataset represents the percentage of soil sealing (including building area) and has a resolution of 20 m. The building dataset is a vector dataset representing the building geometries (accuracy 3-8 m), including heights but without information on the building materials or use."

- 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?

Thank you for pointing out this. We removed the inconsistency in latent heat flux notation throughout the manuscript. We removed the fluxes from Table 3.

- 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?

Thank you for pointing this out. We corrected the description of the CNR4 measurement.

P15, L21-22: "radiation fluxes are measured with a ~~net~~ four-component radiometer"

The comparison with radiation is only shown in the Supplement, since we expected only a minor impact

from street trees.
We added the following explanation regarding the evaluation in terms of radiation fluxes:

P20, L12: "For completeness, the comparison between modelled and observed radiation fluxes is shown in the Supplement. The model simulations agree reasonably well with the observed radiation fluxes, although the upward short-wave radiation is underestimated. This indicates that the albedo is underestimated, which can be related to the choice of material properties (Table 2). The upward long-wave radiation is slightly overestimated, which can therefore be related to the underestimation of the albedo and, consequently, to an overestimation of surface temperatures. Overall, the representation of street trees had a very minor impact on the radiation fluxes."

- 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?

Thank you for pointing out this inconsistency.
There are indeed only five sites since the site of WEIL has not been used.

P16, L4: "~~Six~~ Five surface stations are used …"

- 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?

Thank you for pointing out this inconsistency.

We recalculated the LST with the values of emissivity as used in the model from Loridan and Grimmond (2012) and compared with those recommended by Sobrino et al., (2008) and Baldridge et al., (2009). We added an additional figure in the Supplement (Figure R1) that highlights the impact of this choice on the LST and edited the text with a comment on the uncertainty introduced by this aspect.

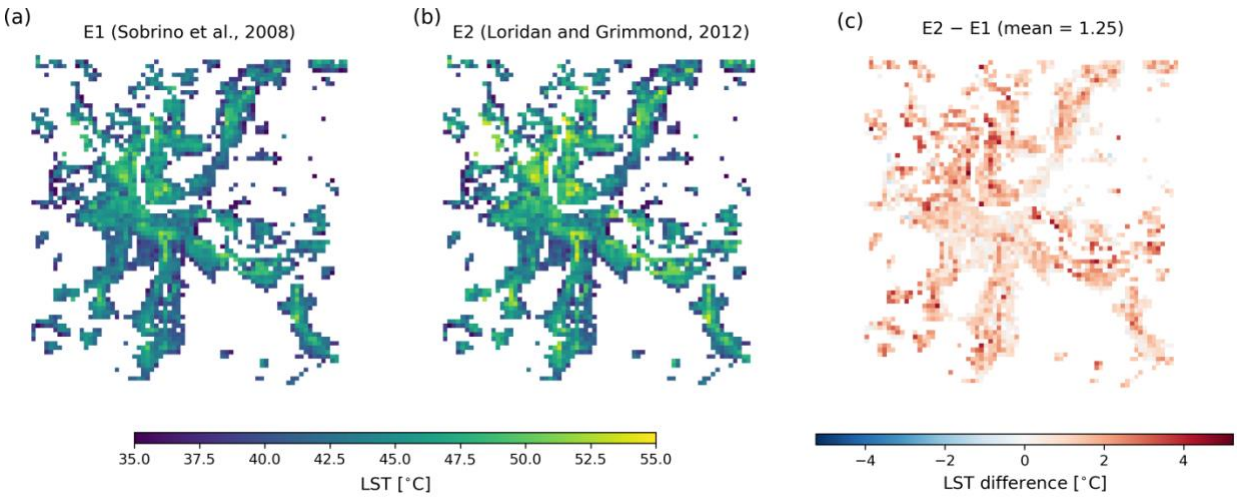

Figure R2 – Impact of the choice of emissivity values for urban surfaces on the land surface temperature (LST). (a,b) show the observed LST with emissivity values from Sobrino et al., (2008) and Loridan and Grimmond (2012), respectively; (c) shows the difference in LST between the two approaches.

"A modified vegetation-threshold approach by Sobrino et al., (2008) was used to estimate the surface emissivity. As the original approach does not account for built-up areas, a lookup table for dark and bright urban surfaces with a range of 0.95 to 0.97, based on emissivity values for typical urban fabrics (Baldridge et al., 2009), was applied (Mitraka et al., 2012). Note that these values differ from those used in the model (Table 2). The uncertainty in the values of emissivity produces average changes in the LST of about 1.25 K (Supplement). On top of this, the LST is affected by uncertainties due to atmospheric correction, sensor and off-nadir view (Voogt and Oke, 2003; Chen et al., 2017) ~~Using the above-described methods, the uncertainty in surface emissivity and atmospheric effects results in a total error of approximately 0.4 to 1.1 K (Jiménez-Muñoz and Sobrino, 2006).~~"

- P17 L15-17: Define f_{dir} here as it does not seem to be defined in the main text

We added a definition of f_{dir} .

P17, L15-16: "…, f_{dir} is the fraction of canyons with direction *d*, …"

- P17 Fig 5 caption: The letters referring to the various panels needs correcting here and in the main text.

P18, Fig5 caption: "Comparison between observations (Obs) and model simulations (STD, LA0) of air temperature (a,b), specific humidity (~~b~~c,d), wind speed (~~c~~e,f), sensible heat flux (~~d~~g,h) and latent heat flux (~~e~~i,l) at the site BKLI (38 m tall flux tower) during the selected simulation period (discarding the first 5 days as spin-up). The left (a,c,e,g,i) and right (b,d,f,h,l) columns show the 3-h moving average and the diurnal cycle, respectively. …"

P18, L1-2: "The model simulates the evolution of air temperature very well during the evaluation period (Figure 5a-b) …"

P19, L1: "The evolution of specific humidity *q* throughout the simulation is generally well reproduced (Figure 5~~a-b~~c-d)."

P19, L9: "The model simulates well the evolution of wind speed (*u*) during the evaluation period (Figure 5~~c-d~~ e-f), ..."

P19, L16: "The sensible heat flux (Q_H) follows very well the observations during the evaluation period (Figure 5~~e-f~~g-h), …"

P20, L4: "The evolution of latent heat flux (Q_E) is generally well reproduced by the model (Figure 5~~g-h~~i-l), …"

- 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.

Following this suggestion, we applied the following changes to the manuscript:

P11, L9: "In this study, COSMO-BEP-Tree was run for the period 22 June 2015 - 9 July 2015, with the first 5 days discarded as spin-up period. The analyses were performed on the period 27 June 2015 - 9 July 2015, called study period hereinafter."

P18, Figure 5 caption: "… during the ~~selected simulation~~ study ~~period (discarding the first 5 days as spin-up).~~ …"

P18, Table 4 caption: "… during the study period ~~22 June 2015 - 9 July 2015 (discarding the first 5 days as spin-up)~~. …"

P21, Figure 6 caption: "…during the ~~selected~~ study period ~~(discarding the first 5 days as spin-up)~~. …"

P22, Table 5 caption: "during the study period ~~22 June 2015 - 9 July 2015 (discarding the first 5 days as spin-up)~~. …"

P24, Table 6 caption: "during the study period ~~22 June 2015 - 9 July 2015 (discarding the first 5 days as spin-up)~~. …"

- 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})

Table 4 is updated with *T* instead of 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}

We agree with the reviewer and changed the text accordingly.

- P19 L10: The wind speed overestimation occurs often: suggest changing 'a few days' to 'most days'

We agree with the reviewer and changed the text accordingly.

- 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?

First of all, we add the prescribed values of roughness length to Table 2. The values correspond to the

default options of the urban canopy model BEP, as used in previous studies (Chen et al., 2011; Salamanca et al., 2011; Hammerberg et al., 2018).

	Roof	Wall	Road
Albedo (-)	0.1	0.1	0.15
Emissivity (-)	0.85	0.9	0.95
Heat Capacity (J m−3 K−1 × 106)	1.5	1.4	1.5
Heat Conductivity (W m−1 K−1)	0.8	1.0	0.8
Total thickness (m)	0.5	0.3	1.0
Roughness length (m)	0.01	-	0.01

Table 2. Material properties used in the urban canopy model.

We agree with the reviewer that wind speed may be sensitive to values of roughness length at individual surfaces. However, we haven't performed any sensitivity studies on the impact of the prescribed values of roughness length. Moreover, we are also not aware of any studies in the literature where this aspect has been investigated in the context of mesoscale modelling with multi-layer urban canopy model.

Nevertheless, a similar overestimation is also observed at the rural site (Figure 1 in the Supplement). In our opinion, this points out to an overestimation of regional scale wind speed rather than local effects in the urban area.

P19, L10: "…The ~~origin of the~~ overestimation was not limited to the urban area but was also found at the rural site (Supplement). Although its origin is unclear, possible causes may be a misrepresentation of the ~~synoptic~~ regional scale wind from the driving boundary conditions and an overestimation of the thermally driven flow induced by the surface temperature gradient between the city and the surroundings."

- P20 L21: 'may be related to exposure of the sensor to local influences' – please explain

We extended the explanation regarding the sensor exposure, as already done when describing the sites (P16, L8).

P19, L10: "This difference may be related to the local exposure of ~~the~~BFEL sensor, located in the vicinity of a (warm) south facing wall."

- P21 Fig 6: Why are no results for BLER plotted here? This would help the reader to interpret Fig 7.

We included the daily profile of air temperature at BLER in Figure 6.

- 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

We included a discussion in order to make it clearer that other model biases were masking the benefit of representing street trees for UHI estimation.

P21 L4-7 "The representation of street trees affects the simulated UHI intensity by producing a slight reduction in UHI intensity from late morning to early evening. The impact of street trees is more evident at sites with higher urban fraction and density of street trees. An improvement in model performance with street trees was, however, not evident in terms of UHI representation. Considering that street trees produce changes in the expected direction, this suggests that probably other model biases are masking the benefit of including street trees. ~~The representation of street trees did not improve the model performance in terms of UHI representation, given that the warm bias at the rural site dominates.~~"

- 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

We thank the reviewer for the suggestion and extended the paragraph with more discussion about uncertainties in satellite-derived LST in urban areas.

P22 L10-12 "The explicit representation of street trees did not improve the agreement with satellite observations of land surface temperature. However, this observation should be taken with care given that satellite-derived LST in urban areas are known to have a large degree of uncertainly due to potential errors in the surface emissivity, sensor and satellite view bias (Voogt and Oke, 2003; Chen et al., 2017). Slight off-nadir view angles can introduce a bias over areas with tall buildings while LST variations at scales below 500 m may be unresolved (Crawford et al., 2018). ~~However, this observation should be taken with care given the uncertainty in the satellite observations of the order of 1 K.~~"

References:

Voogt, James A., and Tim R. Oke. "Thermal remote sensing of urban climates." Remote sensing of environment 86.3 (2003): 370-384. https://doi.org/10.1016/S0034-4257(03)00079-8

Chen, Feng, et al. "Challenges to quantitative applications of Landsat observations for the urban thermal environment." *Journal of Environmental Sciences* 59 (2017): 80-88. https://doi.org/10.1016/j.jes.2017.02.009

Crawford, Ben, et al. "Variability of urban surface temperatures and implications for aerodynamic energy exchange in unstable conditions." Quarterly Journal of the Royal Meteorological Society 144.715 (2018): 1719-1741. https://doi.org/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?

We thank the reviewer for the suggestion and included an explanation.

P26, L3-4: "A reduction in the leaf area density (LA-) generally produced an opposite response to that of an increase in leaf area density (LA+). An interesting exception is T_{air} at night, suggesting that different processes with opposing sensitivities to values of LAD are at work. The largest night-time reduction in T_{air} was achieved with LA-, which was associated with a similar reduction in T_{str}. A slight reduction in T_{air}, however, was also found for LA+, which contrasts with an increase in T_{str} for this scenario. This points towards complex, non-linear interactions between the different effects of LAD on radiation and winds. However, further studies are needed to corroborate this finding."

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

We thank the reviewer for the careful inspection of the manuscript and have adopted it accordingly.