The authors would like to thank the referee for the review of the manuscript and we appreciate their remarks and suggestions for improving the quality of the manuscript. The responses to the comments can be found below, in which we refer to the revised manuscript containing the track changes, see http://www.geosci-model-dev-discuss.net/gmd-2016-58/gmd-2016-58-AC2-supplement.pdf.

Please note that some line-breaks are missing in the version with the track changes, a drawback of using latexdiff (mostly in combination with citations). Therefore, we also provide the new revised version without track changes www.geosci-model-dev-discuss.net/gmd-2016-58/gmd-2016-58-AC3-supplement.pdf.

A word of thanks will be provided in the next manuscript versions.

General comments

This study evaluated a scheme for deriving bulk urban parameters from urban canopy parameters and then applying them in a meteorology model with a bulk urban model. The purpose is to better account for urban effects without the additional complication and computational burden of a more detailed street canyon model. I think that this approach is a good compromise between bulk models that designate parameters according to land use category and urban canopy models that require detailed urban morphology and high resolution grids (vertical and horizontal). However, its value over existing bulk approaches would be greatly enhanced if there were a simple way to acquire the urban canopy parameters used by SURY for any user specified domain. If we are practically limited to using default values for the canopy parameters, the result is just a modified bulk model with little added value since it would not distinguish between different cities. Thus, it would be helpful to those of us who are tempted to use this approach if some additional guidance could be provided on how to easily acquire and process the needed urban canopy parameters.

While the paper clearly presents the study, I feel that the study has two main deficien cies. One is that the primary function of the SURY, which is to incorporate geographically specific urban canopy parameters into a simple bulk urban scheme is never really demonstrated. If it is too difficult for the developers of SURY to apply it to its full extent with actual canopy parameter data at the model grid resolution for a few cities in their domain, then it is unlikely that others would find it very useful.

The authors agree that the final goal of the methodology is the application of detailed spatially-varying canopy-parameter datasets - distinguishing between the different residential, commercial and industrial areas - into existing bulk urban land-surface schemes. Just like any other land-surface scheme including the more complex explicit canyon models, the presented methodology is dependent on the availability of urban-canopy parameter (UCP) datasets. Many efforts for acquiring such parameter datasets already exist (as listed see below). The following types of datasets exist:

- Firstly, **detailed urban parameter inventories** exist for different campaigns over specific sites around the world (see e.g. the Preston site (Melbourne, Australia) in the Grimmond et al. 2011 Phase II Intercomparison paper). They are applicable for the specific urban terrain under scope (eg., applicable for offline urban climate modelling), but they do not include the city-wide variability
- Secondly, there are **detailed city-scale varying parameters**, but only for specific parameters and for specific cities, eg., CityGML 3D-urban canopy structure for Basel and Berlin (Schubert et al., 2013).
- Thirdly, **global datasets for urban-canopy parameters** exists, particularly that of Jackson et al. 2010 (based on site-specific parameter inventories worldwide). Based on 4 urban categories within 33 regions in the world, it provides information on the spatial extent, urban morphology, and thermal and radiative properties of building materials. Such datasets are intended for accounting for the urban-parameter variability on the global scales suitable for application in global climate modelling. Because their focus on the global scales, they do not to intend to deliver accuracy and detail on the scale of the cities needed for regional climate applications. In particular, the databases does not provide the variability in thermal and radiative parameters among the different urban classes and the additional spatial variability within one of the 33 region like Western Europe.
- Finally, the **local-climate zone classification (LCZ)** system (www.WUDAPT.org) aims to address these deficiencies. It provides recently developed tools (Stewart and Oke, 2012; Bechtel et al., 2015; See et al., 2015) for facilitating a coherent and detailed **urban canopy parameter dataset** with a world-wide coverage (more details can be found in the revised text at ...). However, such a dataset is currently under development. Specifically for the region under scope, the authors are currently involved in mapping the LCZs for the 3 largest Belgian cities (Ghent, Antwerp en Brussels) and are developing a new automated methodology to efficiently link these zones with morphological, radiative and thermal properties (Verdonck et al., submitted to Remote Sensing).

It is clear from the above that existing spatially-varying parameter datasets are currently under development, and this is particularly the case for the current evaluation region. Although the authors could not yet provide additional experiments that include more detailed spatially-varying UCP information, the authors are confident that our current study contains an important leap in urban climate research towards efficient and precise convection permitting **urban atmospheric modelling (Prein et al., 2015)**: The development of SURY anticipates on the ongoing UCP dataset advancements by making them applicable in existing bulk urban land-surface schemes. Hereby, the implementation procedure would be that UCPs are taken directly as input for

SURY translating them into bulk parameters for efficient urban atmospheric modelling. Therefore, the presented SURY framework will have wide applications in future studies noting the increasing interest and dataset development in the WUDAPT framework, the substantial amount of existing bulk schemes, the demand for efficiency and consistency in (ensemble) climate assessment and numerical weather prediction, and the need for more detailed parametrizations (Best and Grimmond, 2015). It should also be noted that the parameter sensitivity with SURY coupled to COSMO-CLM allowed us to make recommendations in the development of the UCP datasets.

As an intermediate solution, the current manuscript has developed a default set of UCPs in section 2.1, which combines SURY's theoretical framework, detailed existing urban-canopy parameter inventories, and modelling and observational studies.

We agree with the reviewer that the clarity 1) regarding the added value and future applications of SURY, and 2) about our recommendations with respect to the development of UCP datasets should be improved. Hereby, the SURY development should be better situated in existing literature (as explained above), and also the information about gathering and employing (upcoming) LCZ-based UCP datasets should be provided. Therefore, the authors propose to make the following text changes:

- in the introduction at P3R5-R31 (overview parameter sources), P4R3-R16 (added value SURY anticipating on more detailed parameter datasets)
- in the model setup: P13R15-R20 (motivating the use of the default parameter list).
- in the discussion and conclusions: P29R5-R19 (UCP application of SURY), P31R15-P33R3 (recommendations regarding the development of UCP datasets and their applications in atmospheric modelling) . Hereby, P32R1-R11 provides information about how to obtain more detailed datasets in future applications.
- and in the abstract: P1R17-P2R3

The other main deficiency is that the base model used in this study has significant errors in temperature simulation which obscures the evaluation of the urban parameterization and the sensitivity of the parameter uncertainty. I suggest that these deficiencies be addressed before publication.

For addressing this general comment above, we also take into account the following specific comment:

Page 28, ln13-23: This is a very important paragraph. As this paragraph points out, errors in the base model are obscuring the evaluation of the SURY and Urban scheme and the sensitivity analysis of the parameter uncertainty. Since, these errors undercut the value of this study it seems like some effort should have been made to reduce these errors.

The authors are aware of the fact that general model performance may obscure the evaluation of SURY and parameter uncertainty. Hereby, the authors need to stress that the current manuscript provides - to our best knowledge - one of the most comprehensive online evaluations with regard to the modelled urban heat islands, that both include BLUHI, CLUHI and SUHI. On the one hand, such a comprehensive analysis depicts the strengths of the coupled model system, eg., the ability to capture the diurnal and daily variability of the different urban heat islands. On the other hand, this extensive evaluation also reveals deficiencies, particularly, a general underestimation of the diurnal amplitude of nocturnal temperatures, urban heat islands and vertical temperature profile stability. In this respect, the authors agree with the reviewer that the SURY methodology is subject to deficiencies of the host model. However, such an undercutting could also happen for any other urban land-surface modelling strategy different from the SURY-methodology coupled to this or another host atmospheric model. In this respect, the URBMIP coupled model experiment (Trusilova et al., 2015) has shown that different urban land-surface parametrizations coupled to the same model share these similar issues.

Furthermore, addressing the underlying errors of the host atmospheric model is an enormous challenge. Hereby, fully-coupled atmospheric model systems deal with feedbacks between soil(-moisture) processes, atmospheric circulation, radiation, turbulence, cloud microphysics and land-atmosphere interactions. In the particular case of COSMO(-CLM), there are mainly two research communities (COSMO consortium and the CLM community) with over 200 people that are dealing with the improvement of the different atmospheric model components. Amongst others, recent efforts include the implementation of vegetation shading, improvements in the surface-layer and boundary-layer turbulence scheme, a new resistance formulation for bare soil evaporation and the improvement of cloud radiation coupling as a consequence of a recent published work by Brisson et al. (2016). For the current manuscript, the authors have tested different host model parameter set-ups, which could already improve the nocturnal boundary-layer stability and consequently the urban heat islands. This is particularly achieved by altering the settings of COSMOs boundary-layer turbulence scheme and taking into account soil-moisture conductivity (Schulz et al., 2016).

It should be noted that the urban parametrization in the COSMO-CLM model already provides an overall improvement regarding temperatures and urban heat islands (see P30R27-R28), particularly an alleviation of negative temperature biases in the urban areas (see P30R25-R28). As soon as other issues in the host atmospheric model are solved, additional benefits of SURY (and upcoming LCZ-based UCP datasets) will come forward automatically. Our previous study Wouters et al. (2013) indeed shows that general model improvement interacts with urban-climate modelling performance: Herein, it was shown with an idealized boundary-layer model that the model representation of the boundary-layer (directly affected by surface-atmospheric interaction) is important for well-capturing the urban heat island. For instance, an overall underestimation of nocturnal stability found in the host model gives rise to an underestimated nocturnal canopy-layer urban heat island. We agree with the reviewer that the context regarding the urban-climate modelling performance should be addressed in more detail in the text. Therefore, we now provide a separate paragraph at P30R27-P31R4.

Despite the model errors, the authors are confident that the development of SURY and the online evaluation and sensitivity study provides a substantial added value to existing literature: it has enabled us to formulate recommendations for more precise urban-climate modelling at the convection permitting scales (hence the SURY methodology coupled to COSMO-CLM model features an efficient test bed): Particularly, the sensitivity of the UCPs relative to the overall model errors indicates the (relative) importances of both the ongoing advancements in the urban canopy parameters (see above) and in the atmospheric model system for more reliable urban climate modelling. In order to make our recommendations more clear for the reader, the following changes are made to the manuscript:

- in the results section: P17R24-R25 and P24R17-R19 (model performance)
- in the discussion and conclusions: P30R27-P31R4 (discussion about atmospheric model performance), P32R21-P33R3 (recommendations regarding atmospheric model improvement and urban-canopy parameter improvements)
- and in the abstract: P1R13-P2R3

Specific comments:
Page 6, ln4: what is SAI for natural land cover? Is it LAI?

SAI refers to the The Surface Area Index, which is defined as the ratio between the land-surface area - that envelops the urban canopy - and the plan area. The definition can be found at P5R29-P6R2

Page 6, ln9-10: What is “this parameter”? I’m guessing that you are saying that the depth where the urban substrate changes to soil is equal to the building height h. Is this correct? If so, why should the substrate depth be equal to the building height? Please explain.

Indeed, ‘this parameter’ refers to the thickness of the ‘urban substrate layer’. The latter is introduced for representing thermal properties of the urban canopy in thermal contact with the natural soil layer below. This represents the (thermal mass of the) buildings and as such its thickness equals the building height H. In order to make the formulation and definitions more clear, we have revised the corresponding paragraph (see P7R24-P8R18)

Page 18, ln9-10: These large biases in day and night LST and the under predicted diurnal range make it difficult to evaluate the urban model. How do you account for these errors in the base model when evaluating the UHI results?

As clear from Fig. 4, biases are of similar magnitude for the different urban classes and the rural class. As a result, the SUHI, calculated as the difference between each urban class and the rural class, is well reproduced by the model compared to the observed SUHI, as indicated in the text.

Page 21, ln18-21: This discussion does not agree with Figure 5. It looks to me that the REF model underestimates the stable lapse rate between the lowest 2 observations at the rural site meaning it's less stable not "more stable". Figure 5 also shows that the UHI is underestimated near the ground due to the overestimation of the rural T.

It is true that the model shows less stable lapse rates than the observed lapse rate. However, the model is still able to reproduce the contrast between the urban and rural site, ie. the more stable boundary layer in the rural site compared to the industrial site. We now state this more clearly in the text: P24R17-R19

Hereby, it should be noted that the mentioned model issues with the boundary-layer stability are indicated at P24R14-P25R17 and P30R31-R32

Page 24, ln13: Why would lower roughness result in lower windspeed?

Indeed, 'lower wind speed' should be replaced with 'higher wind speed', which is now changed in the revised manuscript (see P27R13). In that case, the reduced accumulation of excess urban heat and the lower temperature mentioned in the next sentence also makes sense.

Page 28, ln13-23: This is a very important paragraph. As this paragraph points out, errors in the base model are obscuring the evaluation of the SURY and Urban scheme and the sensitivity analysis of the parameter uncertainty. Since, these errors undercut the value of this study it seems like some effort should have been made to reduce these errors.

This comment is addressed together with the general comments. See above.

Page 30, ln19: How is transpiration modeled? There should at least be a reference

This is added at P35R5-R8

Page 30, ln26: where does Fm come from?

Fm (maximal moisture flux that the soil can sustain) is adopted from formulation of Dickinson (1984). The reference is added to the revised manuscript at P35R15

Page 31, ln1: shouldn't rsa differ for heat and moisture?

The COSMO-CLM model considers the transfer resistance for 'scalars', which refers to both ‘heat’ and ‘moisture’. This was made more clear at line P35R17

Technical comments:

We will adopt the technical comments in the revised manuscript. Where necessary, explanations are given below.

Table 1 caption last sentence typo: Hereby

Agreed. See P6

Page 5, ln13: what is meant by lateral heat transport? “. . .within through. . .” doesn’t make sense

The sentence is reformulated at: P6R4-R5.

Page 9, ln28: typo – Parater should be Parameter?

See P12R3

Page 10, ln3-4: This sentence in incomplete. It’s missing a verb.

‘according to’ is replaced by ‘is according to’, see P12R14

Page 13, ln32: typos – missing period after thermocouples, temperatuere is mis spelled.

See P16R25

Page 21, ln3: Are the values given here for SUHI bias? Should say so.

Indeed. This is now indicated at P24R2.

Table 6: Are the values averaged vertically? Please explain what these mean. Also, I don’t see an “R” column.

Yes, the values are vertically averaged. The revised text can be found at the figure caption on P25.

Page 28, ln18: “overwhelm” might be better than “overrule”

We agree that “overrule” is misused. We replaced it with “exceed”, see P32R21-R27

Page 28, ln24: “natre” should be “nature” see P33R4

Page 31, ln7: This seems to be an errant line

The line has been removed from the manuscript, see P35R23

Page 32, ln16: “withouth”

see P37R2

Page 33, ln7: should be 49.16 W m-2

see P37R28