In addition to our previous replies in black font below, we have now included an additional red font that provides additional information and points to the location of the changes in the revised manuscript. The latter can be found at 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.

The authors would like to thank the referee for the review of the manuscript. We appreciate the suggestions for clarifying the manuscript in some of its key points. As part of the interactive discussion of GMDD, we provide a reply to the different reviewer's comments. A definitive answer will be provided at the time of the revision, in which the necessary changes will be indicated in the revised manuscript.

General comments:

This paper boasts to present a Semiempirical URban-canopY parametrization SURY, which bridges the gap between bulk urban land-surface schemes and explicit-canyon schemes. But it lacks the comparison between the bulk urban schemes and explicit-canyon schemes….

The authors agree that model intercomparison studies comparing bulk schemes on the one hand and the explicit-canyon schemes on the other hand are important to substantiate the development and advantages of SURY as an 'in-between' model approach. In this respect, *the introduction in our paper summarizes a qualitative comparison between the bulk schemes and the explicit canyon schemes (see P2R9→P3R8). For the revised manuscript, we will add the references to studies that compare the different schemes as follows (at P2R10): "Even though their purpose of representing urban physics in land-surface schemes of atmospheric models is the same,* ***intercomparison studies (Grimmond et al., 2011; Best and Grimmond, 2015; Trusilova et al.2015; Karsisto et al., 2015) demonstrate*** *that they differ in terms of modelling strategy, complexity, input parameters and applicability"*

see P2R15 [or P2R9 in the version without the track changes]

Furthermore, the intercomparison studies support our model development for bringing canopy-dependent urban physics to existing urban bulk land-surface schemes (see in bold just below), also allowing to consolidate urban canopy parameter datasets with urban bulk parameters (as stated in our conclusions). Therefore, the following information is to the revised introduction as well (at

P2R29): “*At first, the urban canopy parameters, which include information about* ***the three-dimensional*** *urban morphology and material properties, are obtained from detailed inventories (Loridan and Grimmond, 2012; Jackson et al., 2010).* ***The first urban model intercomparison project demonstrate that such parameter information is important for improved modelling performance in existing urban land-surface schemes (Best and Grimmond, 2015).”***

This is covered in the revised introduction paragraph: P3R9-R27

Finally, a full quantitative comparison between urban land-surface schemes, which is covered by existing studies as mentioned above, is outside of the scope of this paper about the specific development of SURY.

… So, I question whether the SURY scheme is necessary or not.

The authors agree with the reviewer that the added value of SURY over existing methodologies needs to be stated very clear in the manuscript. Therefore, we will include the following information as bullet-points in the revised introduction (at P3R10):
- (*as already stated in the introduction*) Based on detailed observational studies, modelling experiments and available parameter inventories, SURY represents a robust translation of urban-canopy parameters containing three-dimensional information towards bulk parameters.
- the translation allows to combine advantages (hence bridges the gap) of both bulk schemes and explicit-canyon schemes in urban modelling studies. Especially, **it brings canopy-dependent urban physics** (used to be reserved for the explicit-canyon schemes before) **to the existing urban bulk land-surface schemes.** This could be done while preserving the low computational cost and low complexity of the bulk schemes.
- the translation offers versatility and consistency in choosing between urban-canopy parameters from bottom-up inventories and bulk parameters from top-down inventories.

This is covered more explpicitely at P4R3-R17

Note that a more extensive discussion about advantages (and limitations) of SURY with regard to applicability, versatility, model consistency and the computational cost is provided in the 'discussion and conclusions'-section, see R26R1→R27R14 and R28R24 → P28R34.

This is now covered more clearly in the revised manuscript at P29R5-P30R19 and P33R4-R18

As for SURY, why the author choses these parameters namely bulk albedo, bulk emissivity, etc. as the output of SURY, this need to be clarified.

Such a choice was made for making the SURY methodology generally applicable in existing bulk urban land-surface schemes. This information will be stated more clearly in the revised introduction, as shown in **bold** above.

Surface-Area Index (SAI) is a crucial important factor in this paper to reparametrize the ground heat transport parameters, but why SAI is chosen to do this? Why these parameters need to be reparametrized?

It is true that the SAI is an important parameter in the presented methodology. The physical reasoning for taking into acount this parameter (hence its importance) is given in section 2.1.1 (P5R1 → P5R29). This explanation will be better framed in the revised manuscript at the beginning of Section 2.1 as follows (starting at P4R1): *"In this section, the Semi-empirical URban canopY parametrization SURY is described. The translation of urban canopy parameters into urban bulk parameters takes into account the urban physical processes with regard to the ground-heat transport ~~(see Section 2.1.1)~~, the surface-radiation exchanges ~~(see Section 2.1.2)~~, and the surface-layer turbulent transport for momentum, heat and moisture ~~(see Section 2.1.3)~~**: The bulk thermal parameter values take into account the enhanced ground heat transport due to the increased contact surface with the atmosphere (see Fortuniak, 2004) expressed by the Surface-Area-Index (SAI) in Section 2.1.1. Furthermore, the radiative bulk parameter values take into account the albedo reduction factor resulting from the radiative trapping by the urban canopy in Section 2.1.2. Finally, the enhanced surface drag on the wind by the buildings in the urban canopy take into account the building height in section 2.1.3.** As a result, SURY introduces an efficient dependency of bulk urban land-surface schemes to the canopy parameters. **Throughout the subsections below,** the robustness of SURY is verified by comparing bulk parameters from top-down estimates with those translated from bottom-up urban canopy parameter inventories. Default values of the urban canopy parameters and those of the translated bulk parameters are determined. An overview of the urban canopy parameters (SURY input) and the bulk parameters (SURY output) is given in Table 1."*

The revised text can be found in the revised manuscript at P5R8-R20

Specific comments:

1. Page 4 Table 1: I think these parameters should be reworked because they are varied with different areas.

The authors agree that the urban-canopy parameters depend on the area under scope. As denoted in the introduction, these parameters are not always available in a consistent dataset, hence it is chosen to obtain and list a set of default parameter values derived from available datasets.

More particularly, the authors agree that the methodology should employ more 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. The development of SURY anticipates on the ongoing UCP dataset advancements by making them applicable in existing bulk urban land-surface schemes. As an intermediate solution, the current manuscript has developed a default set of UCPs in section 2.1 (table 1), which combines SURY's theoretical framework, detailed existing urban-canopy parameter inventories, and modelling and observational studies. More detailed spatially-varying urban-canopy parameters can be employed as soon as they become available.

In order to integrate this information more clearly in the manuscript, 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)
- and in the abstract: P1R17-P2R3

2. Page 6 Equation 3: Please explain why use this equation to reparametrize the parameters.

The formula can be obtained from geometrical considerations of an idealized parallel urban canyon with straight roads and flat roofs. The first term (1+ 2H/W) (1-R) represents the surface area index of the street canyon. In turn, it is subdivided in 1 x (1-R) which is the surface area of the street, and 2 H/W x (1-R) which is the surface area of the two walls in the street canyon. Finally, the second term R represents the surface area index of the roof.

It is added at P7R10-R21

3. Page 7 Equation 10 and 11:
These equations also need to be explained.

In Equation 10, ψ_{bulk} is the total albedo reduction factor of the urban canopy. The reduction factor is weighted according to the roof fraction R and the complementary street-canyon fraction (1-R). As stated before, flat roofs are considered, hence the roof fraction R does not lead to a albedo reduction. In contrast, multiple reflections take place for the street-canyon fraction (1-R) for which the canyon albedo reduction factor ψ_{canyon} is taken into account expressed by Equation 11. As already stated in the manuscript (P7R19 and further), equation 11 approximates the numerical estimation of Fortuniak (2007). This information will be supplemented to the revised manuscript.

See P9R20-R24

4. Page 8 Line 22: In my opinion the z0 is the most important parameter in surface layer turbulent fluxes parametrization, so I think at least z0 should be added in the sensitivity analysis.

Agreed. As z0 (output of SURY) depends on the building height H (input of SURY) through Eq. 15, the sensitivity of the former is already covered by the 'EL' and 'EH' experiments.

See P27R12-R17

5. Page 29 Line 5: I think
the author should provide a website of the models.

Thank you for this suggestion. We have made a public repository for SURY on Github under https://github.com/hendrikwout/sury and added this information to the manuscript. Furthermore, this new section now also provides a link to the project page of the modified version of the COSMO-CLM model with TERRA_URB that implements SURY.

The additional information can be found at P33R20-R24