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Interactive comment on "Implementation of street trees in solar radiative exchange parameterization of TEB in SURFEX v8.0" *by* Emilie Redon et al.

Emilie Redon et al.

emilie.redon@meteo.fr

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SUMMARY OF CHANGES

Firstly, we would like to express our thankfulness and appreciation to the reviewers for their useful comments to improve the paper. We have addressed all the comments as explained below.

GENERAL COMMENT: Major changes in the new version of the article

Considering the useful comments of the Referees we proceed to some major changes in the article in order to provide full explanations of the purpose of our experiment and avoid confusion with future works (particularly about the longwave balance). The view factors are based on the equations of sky view factors in Masson, 2000. Those related

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to the high vegetation are defined on all the directions. In this way, the interactions between all the facets of the canyon, the sky and trees are allowed in Eq. A6, A7, A8. Psi(wt) is now expressed for one wall. Specific coefficients are applied, in the shortwave scheme only, to constrain the reflections from the high vegetation toward sky and top part of walls. It ensure the compatibility with the calculations of the long-wave exchanges, for which the same view factors but no coefficients are involved. The statistics are based on the Mean Absolute Error instead of the Root Mean Square Error, according to the suggestion of the Referee 2 and the Willmott and Matsuura works (2005). The section about the sensibility of TEB model to the vegetation layouts have been removed in absence of clear and systematic behaviors in the simulations. We also permuted the figures 8 and 9 (after removing the former figures 8, 9, 10) and changed the figure 9 about the canyon albedos from a comparison SOLENE vs TEB to a comparison TEB reference vs TEB with a tree canopy layer. The physic assumptions (e.g., the nature of radiation, specular or isotropic, during the multiple reflections) are too different to allow an accurate comparison of absorption by canyon surfaces or canyon albedo. All the figures and text have been adapted.

We payed attention to express better the two major objectives of this work:

(1) technical objective of evaluating the geometrical assumptions related to the high vegetation by the confrontation with a model with explicit tree crowns where the radiative budget is solved at high resolution (through numerical meshed mock-ups);

(2) scientific objective for further studies of simulating different vegetation layouts, potentially including urban trees, to provide information about impacts of greening on microclimate, thermal comfort, energy demand by buildings and needs of water to maintain the vegetation at the city-scale.

REFEREE 1Âă:

PART 1 : Points for Correction and Clarification

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1. “ At a number of points you refer to keeping computing times acceptable (e.g. Page 1, Line 7; Page 6, Line 21). It is unclear what is an acceptable computing time is in this context. Do you mean relative to a complex model? How is the representation of this process going to significantly add to computing time? Surely representing the process correctly is more important in the first instance, and computing time shouldn’t determine a limit on how we approach a problem from a modelling perspective as computational optimisation and simplification can be applied later. ”

The TEB model (integrated in the SURFEX land-surface modeling system) has been initially developed for mesoscale modeling, with the objective of including the cities in meteorological models and of being able to simulate the urban heat island. Such applications at city scale entail some constraints about the level of accuracy in the description of urban environment. The model does not pretend to explicitly describe the exact arrangement of streets and buildings, but adopts a simplified approach of mean urban canyons which enables to distinguish the main urban typologies. Even if we are working to improve the TEB model by including new physical processes that seem important to us especially for evaluating adaptation and mitigation strategies, we are committed to maintain a certain level of simplicity. Besides the numerical aspects and time computing, we think that uncertainties associated with the prescription of input data (maps of morphological parameters, materials properties, or vegetation characteristics) significantly limit the potential gain of a very complex modeling. Note that in case of very fine-scale studies, suitable models already exist, e.g. the CFD models, but they are run over much smallest areas.

See page 6 at lines 21-26 the revisions in the paper.

2. “ Page3 Lines 27-31. Since the conference paper of Young et al. (2015) there have been a number of developments relating to the Trees in Urban Areas model (TUrban). The tree representation is not currently implemented within MORUSES (Met Office Reading Urban Surface Exchange Scheme). Instead the scheme has been developed and is currently been tested within the Single Column Reading Urban Model (SCRUM)

as described in Harman and Belcher (2006) and Porson et al. (2009). The view factors for both fully visible and partially occluded facets are calculated analytically based on Hottel's crossed string construction (Hottel 1954). A paper is about to be submitted on this method to Boundary-Layer Meteorology but unfortunately to have gone through the review process in time for this papers publication (Young et al, 2016). These sentences need amending in light of this new information. "

We apologize for our confusing description on TUrban developments. We noted the Referee's information and consequently amended the text.

See page 3 at lines 28-32 the revisions in the paper.

3. " Section 3.2. You talk about improvements of the radiation budget but only mention the longwave radiation budget on Page 6 Line 3. How is this to be modelled for the high vegetation? Although the paper is focused on shortwave radiation it would add to the paper if you described briefly how longwave radiation is treated. "

Here, we made the choice to focus on solar radiation budget for two main reasons. The comparison to the SOLENE model is not suitable for infrared radiation budget, because the two models deal differently with the resolution of surface turbulent exchanges and the calculation of surface temperatures of urban facets. The comparison SOLENE vs TEB for the calculation of infrared radiation fluxes becomes consequently tricky, since these fluxes are strongly dependent on surface emissions. The validation of our shortwave radiation scheme contributes to verify our future longwave radiation scheme because the same view factors are used for the calculations of multiple reflections in shortwave radiation but also infrared radiation exchanges. Specific coefficients are now applied, in the shortwave scheme only, to constrain the reflections from the high vegetation toward sky and top part of walls. It ensure the compatibility with the calculations of the longwave exchanges, for which the same view factors but no coefficients are involved. In nature, the solar radiation is mainly redirected upwards by the receiving face of sunlit leaves in the top of crown during the first reflection. We sug-

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gest here to neglect the small amount of shortwave radiation which the tree stratum is supposed to reflect to the low part of the canyon during multiple reflections in favor of representing realistically the upward first reflection of solar radiation, which is by far the most energetic reflection. On the contrary, emission of longwave radiation by the vegetation is intrinsically isotropic and can reach all the viewed canyon facets. In this case, all the leaves of the crown, statistically associated to all orientations, participate to the emission.

We added further explanations in the paper page 6, at lines 12-17 and page 10-11, at lines 26-28 and 1-5.

4. " Page 6, Lines 24 – 30. The hypothesis about street trees and why they are confined within the canyon is not particularly compelling without explicit examples of such rules on tree management and location. Is this specific to France? Surely the justification is more to do with the model assumptions of the canyon and roof being treated separately in the modelling of the surface energy balance in that the canyon and roof are assumed to be independent of each other? Either that or are you just considering the effects of trees that are not taller than the buildings, as to consider these is not possible within the current TEB configuration? "

Choices on model developments are firstly driven by observations. We refer to the typical positions of trees in urban environment. Depending on the urban form, we observe different vegetation layouts in the townscape. Large avenues of six or height-storey buildings are generally tree-filled with a double row of trees (e.g., Aesculus hippocastanum, Platanus x acerifolia) which the mature height is near the same of the buildings height, around 20 m. The top of trees is commonly cut in order to provide neat and homogeneous sky line and facilitate the long-term management. Along the second or third order streets axes, smaller trees are planted such as Tilia x euchlora or Acer platanoïdes 'Globosum'. At the center of urban groups, squares are greened with grass and trees. In addition to the road, the places are surrounded by wide walkways and recreational areas equipped by benches; so the distance from trees to buildings is sig-

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nificant. Some single specimens can be found in crossroads of boulevards and second order streets or at roundabouts. Each planting in the public area of cities is submitted to compliance with the local tree management rules. These documents are precisely specifying species chosen in adequacy with the aspect ratio of the street, function and aesthetic of the site. They ensure a satisfactory juxtaposition of trees with urban structures for the dwellers (by avoiding excessive shade of trees on facades or disruption of underground services by roots) but also prevent damages of roots by potential new soil removing. It is stated as fundamental urban design principle that streets with 1:1.4 aspect ratio are unsuitable for tree planting. Typically, trunks are planted at least at 3 to 5 meters from walls or balconies. The minimum distance between crowns and walls or balconies is 1.5 meters. In case of not appropriate tree planting, for example in the Queen's Park Estate where London planes would overwhelm the three-storey Victorian buildings of the estate, trees have been pollarded to just below eaves level. In suburban areas or private gardens, common-sense rules are applied in the same way in planting tree to several meters (at least the house height of distance) from walls to avoid obstruction of windows, damage of roots on water pipes or swimming-pools but also falling trees onto housings. Following these practices, we observe a great shading effect on facades but they generally can't shade roofs both in urban and suburban areas.

Even if some tall trees have been planted without respecting elementary requirements specifications, it is a statistically very limited design. It could be occur mainly in suburban or commercial zones. Places that could be concerned by significant impacts on the energy balance of the roof are places located in low or mid latitude because of a higher sunlight. The potential bias would occur in the early morning or the late evening when the Sun is low on the horizon to allow the shadow cast to reach a significant part of the roof. However, the solar radiation is far lower energetic than around the zenith when the shadow cast can't extend to the roof. So, the potential bias would be very small.

In addition, this process is by far marginal and supposed to have a limited impact on the microclimate within the canyon. Indeed, at 2 meters height, the impact of roof shading on air moisture and temperature could be considered as negligible. Remind that the purpose of this paper is to reduce the uncertainties of the prediction of the impact of urban planing (including greening) on thermal comfort of pedestrians.

Regarding these widespread practices and physical elements of discussion, the implementation of the process of shading of trees on roofs was not a priority for our team but remains technically a feasible project.

We added further explanations in the paper page 6-7, at lines 30-32, 1-8.

Bibliography: “Cahier de l’espace public, Chapitre II: Les arbres d’alignement”, Mairie de Toulouse, 2008 (in French) “Street tree Management in Barcelona”, Barcelona City Council, 2011 (in French) “Streets for all: A guide to the management of London’s streets”, Historic England, 2000 “Buildings height in the Royal Borough”, Royal Borough of Kensington and Chelsea, “British Standard 5837: Trees in relation to construction âĂŤ Recommendations”, British Standards Institution, 2005 “Trees and the Public Realm (draft version)”, City of Westminster, 2009

5. “ Page 16, Lines 9-10. The use of the words ‘good’ and ‘only’ are very subjective. You need to state what is it good relative to? ”

We agreed with the comment of the Referee and reformulated the interpretation of the results.

See in section 6.3 the revisions in the paper.

6. “ Section 6.4. This section on sensitivity to vegetation layout characteristics and associated figures is not particularly clear. Statements are made without the use of statistical values nor clear comparison using examples from the relevant figures (Figs 8– 10). Page 16 Line 19 states ‘The comparison of statistical scores’, these statistics need to be presented within the text or in a table. ”

Since we have not highlighted any significant and systematic patterns by studying the effect of tree horizontal coverage, tree canopy height, and tree location, we propose to remove this section which does not bring additional interesting information (as well as associated figures 8, 9, 10).

7. " Section 6.4. Figures 8, 9 and 10 do not show any particular clear patterns (there is a lot of scatter and points on top of each other) that allow the reader to determine the full impact of differences in vegetation or whether it was significant, an alternative method for showing this data is required. It is unclear of the utility of comparing two types of error (RMSE and %Err). Could you clarify why you have done this and how this shows how sensitive the model is to these changes? An explanation of this is required in the text. "

See response to comment 6.

8. " Section 6.5, Figure 11. There are four aspect ratios presented in figure 11 what is the difference between h/w = 2 and h/w = 2b? The second is not referred to in the text nor the figure caption. "

We acknowledge that our paper did not provide sufficient explanations about these additional cases, referred as "h/w=2b" in the former version and referred now (in the updated version) as "h/w=2 rescaled vegetation". These cases show identical urban morphology than classical h/w=2 cases but vegetation layer is doubly thicker and higher than h/w=0.5 and h/w=1 cases for each vegetation configurations in order to rescale it for higher buildings and verify the effect of adapted vegetation layouts regarding to the typology of the street (Cf Fig. 02 and section 5.2.1).

We hope that the readers will find clearer presentation of h/w=2b cases in page 12, at lines 20-24.

9. " Appendix A. Why is the view factor between the road and the tree = 0? Surely this would have an implication when calculating the canyon longwave radiation balance as

the road will see the underside of the tree layer. ”

In the updated version of the paper, the view factors are based on the equations of sky view factors in Masson, 2000. Those related to the high vegetation are defined on all the directions. In this way, the interactions between all the facets of the canyon, the sky and trees are allowed in Eq. A6, A7, A8. It ensure the compatibility with the calculations of the longwave exchanges, for which the same view factors but no coefficients are involved. In addition, specific coefficients are applied, in the shortwave scheme only, to constrain the reflections from the high vegetation toward sky and top part of walls. In nature, the solar radiation is mainly redirected upwards by the receiving face of sunlit leaves in the top of crown during the first reflection. We suggest here to neglect the small amount of shortwave radiation which the tree stratum is supposed to reflect to the low part of the canyon during multiple reflections in favor of representing realistically the upward first reflection of solar radiation, which is by far the most energetic reflection.

See page 10, at lines 26-28 and page 11 lines 1-5 the revisions in the paper.

Part 2 : Grammatical and Format Errors

1. “ TITLE. The authors may wish to amend the title to read more clearly as ‘Implementation of street trees within the solar radiative exchange parameterization of TEB in SURFEX v8.0’. ”

We changed the title in accordance with the suggestion of the Referee.

2. “ ABSTRACT, Line 1. With the first use of an abbreviation the term/phrase/name it is used to abbreviate should be stated e.g. Town Energy Balance (TEB) or TEB (Town Energy Balance). The same applies to SOLENE. ”

We changed the fist mention of TEB to “Town Energy Balance (TEB)” in the abstract page 1 line 1 and in the text, page 2 line 22. According to the team who created SOLENE, the name has no official meaning and it is not an acronym. Nevertheless, they inform me of a defined way of typing the name with capital letters and using a

smaller font size for the 'OLENE' part, consistently with previous papers.

3. " ABSTRACT, Line 3. The word 'obviously' is not required here as it is not obvious without reading the paper that there is increased complexity. It would be more appropriate to state this as a fact by removing the words 'has obviously'. "

We removed the expression 'has obviously' in accordance with the suggestion of the Referee (page 1 line 3).

4. " Page 2, Line 34. 'Surimpose' should read 'superimpose'. "

We corrected this typing error (page 2 line 35). According to the suggestion of the second Referee, we replace 'superimpose' by 'shade' in all the text in order to avoid confusion with contacting surfaces (see comment n°4, part 2 in the section of the second Referee comments).

5. " Page 5, Line 13. The work 'especially' is not required in this sentence. "

We removed this word.

6. " Page 6, Line 32. Should the word 'refined' be 'defined'? "

We corrected this typing error (page 7 line 10).

7. " Page 7, Lines 7 -10. This paragraph is not clear. Should it read as follows? "In order to calculate these terms in TEB, the following section describes how direct solar radiation reaches canyon surfaces. Then, absorption is obtained by separately resolving the first absorption of total solar radiation on each surface and the sum of absorbed shortwave radiation after infinite reflections within the canyon'. "

Thank you for reformulating correctly this paragraph. We changed the paragraph in accordance with the suggestion of the Referee (page 7 line 18-21) and added some details as following : "In order to calculate these terms in TEB, the 4.1 and 4.2 sections describe how direct and diffuse solar radiations reach canyon surfaces. Then, absorption is obtained by separately resolving the first absorption of total solar radiation

on each surface and the sum of absorbed shortwave radiation after infinite reflections within the canyon.".

8. " Page 11, Line 21. Should the first word be TEB on this line? "

We corrected this typing error.

9. " Page 12, Line 15. This first sentence doesn't read well. Consider splitting into two sentences, one explaining that TEB was run with equivalent configurations and another stating the differences between models. "

Thank you for this suggestion. We simplified the sentence (page 13, line 7-8) as following : "In the same way, the TEB model is run for equivalent configurations to SOLENE configurations, respecting hypotheses, approaches, and spatial resolutions differences between the two models.".

10. " Page 13, Line 15. Use of the word 'The' is redundant in this sentence. Start with 'Table 3 presents'. "

We changed the sentence (page 14, line 21) in accordance with the suggestion of the Referee.

11. " Page 13, Line 20. 'Let's remind' is not the correct style nor grammatically correct (Let's = Let is. If using this use 'Lets'). You may consider the following change to the sentence. 'Considering that the temperate climate is characterized by four distinct seasons with contrasting sunshine, air temperature and humidity conditions, seasonal analysis was undertaken'. "

We changed the paragraph (page 14, line 28-29) in accordance with the suggestion of the Referee.

12. " Page 14, Line 27. Incorrect style and grammar using 'let's remind'. The word 'considering' would be more suitable. "

We corrected the sentence (page 16, line 1) in accordance with the suggestion of the

Referee.

13. " Page 14, Lines 27-28. This sentence doesn't make sense. "

Thank you for pointing out this misuse of "Inversely". We reformulated the paragraph section 6.2.

14. " Page 16, Line 5. I am not sure what you mean by 'inversely slightly underestimated'? "

Thank you for pointing out this misuse of "inversely". We reformulated the paragraph section 6.3.

15. " Page 16, Line 20. Misspelt 'exchanges' "

We corrected this typing error (but the section has been removed).

16. " Page 17, Line 9. A missing paper reference at the end of this line. "

We corrected the .bib file.

17. " Page 17, Lines 9-10. Acronyms for models without full model names (as in point 2). "

We added the full names of the cited models page 19, lines 17-18.

18. " Page 20, Line 2. Missing equation reference. "

We corrected the .tex file.

19. " Page 22, Line 1. Misspelt 'example'. "

We corrected this typing error.

20. " Figures 4 and 6. The shades of blue used to represent 'wall A', 'wall B' and 'walls' are not clear and will not reproduce well if printed in black and white. Consider changing colours or using different line thickness. The subplots are also too small, consider reducing white space between subplots. This coul be achieved by limiting the

number of axis labels especially as you are using the same scale and variable on each row. ”

Thank you for these suggestions. We changed the colors and untitled the axes of figures 4 and 4 to allow the reduction of white space between subplots in accordance with the suggestion of the Referee. We hope that description and cited units in captions are enough to understand the figures.

REFEREE 2Âă:

PART 1 : Major comments

1. “ English. Ideally, the English should be edited by a native English speaker. ”

After the revision process and following proofreading we hope that the English is more understandable.

2. “ Error in application of Beer’s law. Equations 3-5 appear to be mixed up. Eq. 4 with albedo removed should be the transmission; Eq. 3 as written is the intercepted radiation (multiply it by scattering coefficient to equal scattered radiation); Eq. 5 should be modified accordingly. Please check your model implementation carefully to ensure that it is correct according to the updated equations, and redo the simulations if the model equations were incorrect. ”

Thank you for pointing out these errors. We corrected the equations 3, 4 and 5, page 8, in the paper. The coded equations were already correct but we run new simulations with the different way to code the option of upwards reflections from the high vegetation using classical view factors and specific coefficients in the shortwave radiation scheme (see response 3 and 9, part 1 in the response of the Referee 1, section 4.4 and Appendix A for further explanations). In addition, some adaptations about the calculation of the attenuation in TEB model have been done for the comparison exercise (see section 5.2.2.). SOLENE applies for each vegetation envelope mesh the same ’full’ attenuation of 0,5 (assuming that it replace the exponential expression above including

the Leaf Area Index). In this way, at each attenuation process, the vegetated meshes in SOLENE attenuates 50% and transmits 50% of the received radiation. Where the Leaf Area Density is involved in the TEB equations (see Eq. B1, B2, B3, B4), we replaced the exponential term by the expression 1 – 0,5(LAD/LAI) to express the transmissivity by modulating the theoretical maximum attenuation of 0,5. Considering the LAD likely to be crossed by rays, we can obtain a transmissivity greater than 0,5 with TEB model. On the opposite, SOLENE can not take into account the layer of leaves where the rays are going through and always apply a full attenuation. The hypotheses of the two models are divergent and results have to be interpreted in the light of this divergence. The authors have amended the text in accordance with the suggestion of the Referees and adapted it to the results of the new simulations.

3. " Neglect of forward scattering. From Eqs. 3-6, it appears that forward scattering of intercepted radiation by vegetation is neglected (see Campbell and Norman 1989 for more detail; also, consider revising lines 7-8 on p. 10). Perhaps the albedo and extinction of the foliage are/can be adjusted to account for this. Either way, please explain and/or justify more fully. Can you assume all scattered radiation is scattered upward without introducing significant error? The broadband scattering coefficient is on the order of 0.50 for the leaves of many trees, and approximately 50% of this is forward scattered – so forward scattering potentially represents 25% of the shortwave radiative energy (very approximately). Interception by lower leaves of radiation forward scattered by upper leaves increases total absorption by tree foliage, which may correct the underestimation you find. "

Thank you for this very interesting comment. We acknowledge that our paper did not provide sufficient explanations about how TEB treats the forward scattering.

As shown in Eq. 2, the direct solar radiation flux potentially received by the high vegetation can be divided into three components: the transmitted part, the reflected part and the absorbed part. In the code, this potential flux reaching the high vegetation is calculated following the Eq. 1 (see page 7, lines 26-28).

For backward scattered (Eq. 4) and absorbed (Eq. 5) fluxes by high vegetation we use the potential received flux (Eq. 1) corrected by the transmitted part (using x (1 - exp (-k LAI))) in the classical equation or x 0.5 in the comparison cases) in order to obtain the part of the incident flux which theoretically reaches only the leaves in the fraction of high vegetation (in other words, holes within the crown have been removed at this stage). In this way, TEB treats the forward scattering of the incident direct solar radiation flux by the high vegetation. Eq. 10 shows that the diffuse solar radiation flux reaching the high vegetation is also corrected by the transmitted part (page 9, lines 17-18). Indeed, we consider that the available flux, deduced subtracting the fluxes received by the other facets of the canyon (using view factors) from the incident diffuse solar radiation, reaches the high vegetation.

The forward scattering computed at infinite reflections between surfaces of the canyon in shortwave radiation is expressed by the tau terms (Eq. B1, B2, B3, B4). These supplementary elements demonstrate that the forward scattering is not neglected during all the processes occurring in the shortwave radiation scheme.

Concerning the backward scattering from the high vegetation, we suggest here to neglect the small amount of shortwave radiation which the tree stratum is supposed to reflect to the low part of the canyon during multiple reflections in favor of representing realistically the upward first reflection of solar radiation, which is by far the most energetic reflection (see Appendix C).

View factors related to high vegetation are based on the height of the middle of the crown (see Appendix A). In this way, the interception by leaves is assumed to be maximum at this level, so the forward scattering within the crown (on the tree fraction) is allowed to this limit. Explicit interactions from leaves to leaves inside the tree crown are not computed in the current version of TEB.

4. " Robustness of SOLENE as evaluation tool. How accurate are the SOLENE calculations of solar absorption and scattering by trees? p. 11, lines 7-8: Treatment of

foliage in the SOLENE should be further discussed, as well as any associated evaluation, given that this treatment is what TEB is being compared to. Details are sparse in Robitu et al. (2006). Does it include forward scattering, multiple reflection between tree foliage and the urban canyon underneath, or between different tree foliage elements, for example? Differences in model geometries between TEB and SOLENE are discussed; how different are the physics? ”

SOLENE model can simulate the radiative budget of a urban scene represented as a numerical mock-up with explicit vegetation layouts where each mesh is associated to a view factor. Sections 5.2.1 and 5.2.2 have been complemented.

The forward scattering is represented by roughly transmitting 50% of the ’incident’ (reaching) flux on the vegetation envelope at the first contact and not a second time when leaving the same envelope by side or toward the ground. Thus, the trees envelopes are considered as semi-transparent.

Multiple reflections are calculated by the radiosity method between all surfaces including tree foliage and the urban canyon underneath or between different lines of crowns. A crucial difference between TEB and SOLENE is the potential interaction between line of crowns. In TEB, we compute a cumulative fraction of high vegetation. In this manner, interactions between tree lines are not taken into account. On the contrary, in SOLENE, when a ray is intercepted a first time by a vegetation envelope and passed through to reach a second envelope, the ray is attenuated a second time (for example for the vegetation layouts (B3, C3, C4). In this way, an horizontal ray crossing twice a vegetated envelope is attenuated in order to release only 25 % of the initial flux when the rays are leaving the second envelope. Additionally, unlike in SOLENE, the attenuation can be modulated in TEB, respecting the surface-surface interaction considered using the Leaf Area Density (see response 2, part 1).

Finally, the multiple reflections are treated in different ways. In TEB the reflections of shortwave radiation are computed in an isotropic way (see Appendix C) while they

are represented as specular reflections in the SOLENE model, using the method of radiosity.

These divergences on the modulation of the attenuation and on the nature of the reflected radiation could partly explain the differences between the received and absorbed solar radiation fluxes of the high vegetation from the two models, apart from the geometrical assumptions.

5. " Large overall albedo difference. The large differences in mean albedo for higher H/W canyons in Fig. 11 are worrying, and suggests to this reviewer than one or more assumptions made in the formulation in the TEB model are inadequate (assuming the SOLENE model is robust – to point 4 above). It could relate to one of points 2 or 3 above. My sense is that tree foliage limited to the canyon should become less important as H/W increases – if that is true, why would performance degrade? Could this be an issue with the TEB shortwave radiation scheme without trees? A primary purpose of TEB is to provide neighbourhood-scale fluxes to the overlying atmospheric model, and overall albedo is the parameter to which the energy balance is often most sensitive. Hence, this result requires more investigation. "

Thank you for this very interesting comment. As explained in the previous response, the calculations of the multiple reflections within the canyon between SOLENE and TEB model are too divergent to allow an accurate comparison of absorbed fluxes. For this reason, we changed the figure presenting the mean daily canyon albedo (Fig. 9) in order to represent the comparison of canyon albedos between the simulations of the reference and current TEB version. The results are in line with our expectations, as discussed in the section 6.4.2.

Part 2 : Minor comments

1." p. 1, line 8: "...uncertainties in terms of the solar radiative exchanges, as quantified by comparison of TEB..." "

Thank you for this better reformulation. We corrected the text (page 1, line 8) in accordance with the suggestion of the Referee.

2. " p.1, line 18: remove "soil artificialisation due to" "

Thank you for this better reformulation. We corrected the text in accordance with the suggestion of the Referee.

3. " p.1, line 22: refresh, or cool, clean/filter, etc? "

Thank you for pointing out this error. We corrected the text (page 1, line 24) with a more suitable term ('these processes cool').

4. " p. 2: "surimpose" is not a word I don't think – do you mean "shade"? And again, p. 6, line 18 I think "shade" or a similar word (obscure?) might be better than "superimpose" (please check throughout). "

Thank you for pointing out this typing error (page 2, line 35). We have chosen the term 'superimpose' in the previous version to express the fact that the high vegetation is located above the ground-based surfaces (road and low vegetation). Indeed, this term could be confusing because the low and high vegetation are not in contact. We amended all the text in accordance with the suggestion of the Referee, using the 'shade' term.

5. " p. 3, line 2: "...by a microscale radiation model: SOLENE..." "

Thank you for this better reformulation. We corrected the text (page 3, line 2) in accordance with the suggestion of the Referee.

6. " p. 3, line 12: Krayenhoff et al (2014) "

Thank you for pointing out this error. We corrected the reference (page 3, line 13) in accordance with the suggestion of the Referee.

7. " p. 4, line 4: "...radiative (Krayenhoff et al. 2014) and dynamic (Krayenhoff et al.

2015) effects..."; the reference for BEP-Tree is "Krayenhoff (2015)" at present. "

Thank you for pointing out this error. We corrected the references (page 4, line 6) in accordance with the suggestion of the Referee.

8. " p. 4, line 6: "...both within and above the canyon and above roofs." "

Thank you for these supplementary details. We corrected the text (page 4, line 8-9) in accordance with the suggestion of the Referee.

9. " p. 4, lines 14-19: There are some significant assumptions in the view factor calculations and radiation exchange in ENVI-met that could be discussed. However, since it is a microscale model, it may not be relevant to go into much detail. "

Thank you for this very interesting comment. We are agree with the comment of the Referee and shortened the description of the ENVI-met model (page 4, lines 15-18).

10. " p. 4, lines 28-29: I suggest beginning the paragraph as follows: "At each mesoscale model grid point, TEB describes the average characteristics of the local environment by a single urban canyon..." "

Thank you for this better reformulation. We corrected the text (page 4, line 25) in accordance with the suggestion of the Referee.

11. " p. 8, line 6: This assumes tree foliage is uniformly distributed across the canyon, if I understand correctly? If so, this is worth stating in the text. "

Thank you for this very interesting comment. We acknowledge that our paper did not provide sufficient explanations about how the processes of interception and transmission of the high vegetation are computed respecting the cover fraction approach. For example, Eq. 1 (page 7 lines 29-30) calculates the direct solar radiation flux potentially reaching the high vegetation, considering the height of trees only. So, it express the flux available at this height, corrected by the shading effects of the walls. In further calculations, we associate the fluxes related to the high vegetation (as the reflected

and the absorbed ones) to the high vegetation fraction (Eq. 6, Eq. 7). That means that the tree foliage is assumed uniformly distributed across the canyon in Eq. 1 (page 8, lines 20-21), as highlighted by the Referee.

12. " p. 11, lines 3-6: Is this relevant, if TEB assumes an isotropic distribution? Presumably the same is chosen in SOLENE? "

Thank you for this very interesting comment. At lines 21-26, page 13, we precise that TEB model is forced with the same conditions of incoming solar radiation than those calculated for the roofs in the SOLENE model. We add a missing element at lines 4-5, page 13: SOLENE has been parameterized to generate perfectly clear cloudless skies. Using a unique forcing for each component (direct or diffuse) of the solar radiation from the SOLENE simulations, TEB forcings do not take into account the non-uniform distribution of incoming diffuse solar radiation on walls. From this imprecision result differences from 1% to 4% between fluxes of the two walls, depending on their orientation, for studied aspect ratios during summertime. Note that an option also allows to represent a non-uniform distribution of the incoming diffuse solar radiation in TEB model but it was deactivated for this experiment.

13. " Eq. 19: RMSD (difference, not error, since you are comparing two models); also note the critiques of RMSD relative to MAE (Mean Absolute Error), e.g. Willmott et al. 2009. I suggest calculation of MAE instead. "

Thank you for this excellent suggestion. We have noted the advantages of using the Mean Absolute Error to quantify the mean error instead of the Root Mean Square Error in our study. Consequently, we present the results of MAE in the updated version of our paper, in accordance with the suggestion of the Referee.

14. " p. 17, line 9: Reference missing. "

Thank you very much for pointing out this error. We corrected the .bib file.

15. " p. 26, line 27: Year is 2015, not 2014. "

Thank you very much for pointing out this error. We corrected the .tex file.

16. " p. 26, line 29: Year is 2014, not 2013. "

Thank you very much for pointing out this error. We corrected the .tex file.

17. " Appendix A, line 1: Eq. ??; and again line 16 on p. 21. "

Thank you very much for pointing out this error (page 22, line 2). We corrected the .tex file.

18. " Appendix A, line 19: View factor from road to trees is zero??? Please explain! "

In the updated version of the paper, the view factors are based on the equations of sky view factors in Masson, 2000. Those related to the high vegetation are defined on all the directions. In this way, the interactions between all the facets of the canyon, the sky and trees are allowed in Eq. A6, A7, A8. It ensure the compatibility with the calculations of the longwave exchanges, for which the same view factors but no coefficients are involved. In addition, specific coefficients are applied, in the shortwave scheme only, to constrain the reflections from the high vegetation toward sky and top part of walls. In nature, the solar radiation is mainly redirected upwards by the receiving face of sunlit leaves in the top of crown during the first reflection. We suggest here to neglect the small amount of shortwave radiation which the tree stratum is supposed to reflect to the low part of the canyon during multiple reflections in favor of representing realistically the upward first reflection of solar radiation, which is by far the most energetic reflection.

See section 4.4 the revisions in the paper.

19. " Appendix A, line 8: LAD is in m2 of leaf area per m3 of volume. "

Thank you very much for pointing out this error. We corrected the text page 23, line 8.

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/gmd-2016-157/gmd-2016-157-AC1-

supplement.pdf

Interactive comment on Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-157, 2016.