Response to reviewer 1 (Prof. Gil Bohrer, Ohio State University)

General Comments – the paper uses LES to determine the mechanisms responsible for increased heat flux from forests with lower albedo then their surroundings. This "convector effect" was previously described by observations. Nonetheless, this manuscript represents a very elegant approach to determine the theory behind this observed effect. They also provide a revised approach to parameterize this effect.

We sincerely thank Prof. Bohrer for the generous comments and the constructive suggestions.

Specific comments: I would be happy if there was an explanation in simple terms of your proposed mechanism behind the convector effect. You are using very technical terms such as "atmospheric coupling", "aerodynamic resistance to heat transfer" and "aerodynamic roughness" but should spend a few lines in section 2.1 explaining this in layman terms, Will help to expand the readership of this, as it is relevant and interesting for forest ecologists, managers and planers, and not only to forest meteorologists. If I got it correctly, the high leaf area of the forest reduces albedo, which leaves more of the incoming energy in the surface. However, the organization of these dark leaf surfaces is such that they are spread over a relatively thick canopy depth (relative to grassland of shrub land where all leaves are condensed in a much thinner layer). Because canopy in dry forests is sparse, wind can easily penetrate it (i.e., they have lower roughness length and displacement height) and can easily exchange heat with the leaf surfaces. Therefore, forests would have intrinsically lower aerodynamic resistance to heat transfer than shorter biomes (with the same leaf area) or other surfaces (with the same albedo). Given eq 1, that would mean higher heat flux.

We thank Prof. Bohrer for pointing this out. This a valuable suggestion. We have added the following text in section 2.1:

"Therefore to summarize canopy convector effect in simpler terms it can be mentioned that the darker and colder canopy surface reduces albedo, which leaves more of the incoming energy on the canopy surface. However, the organization of these dark leaf surfaces is such that they are spread over a relatively thick canopy depth (relative to grassland or shrub land where all leaves are condensed in a much thinner layer). Because canopy in dry forests is sparse, wind can easily penetrate it and can easily exchange heat with the leaf surfaces. Therefore, forests would have intrinsically lower aerodynamic resistance to heat transfer than shorter biomes because of the higher roughness.

Moreover, the same forest (with the same *physical roughness*) could have higher *aerodynamic roughness* and consequently lower aerodynamic resistance to heat transfer for more heat stressed conditions. Given eq 1, that would mean higher heat flux. Thus while CCE would always be present in a forest compared to a grass or shrubland because of the obvious roughness difference, we establish that CCE can also be present within the same forest for different conditions of heat stress- which is a more subtle point and will be further discussed in the following sections by using large eddy simulations (LES)."

Eq1 – by this equation, you are assuming the big-leaf equivalency. The reality is more complicated, as you identify later (P3 L5). I would restrict the statement in P2 line 26 "it is important to recall that, when adopting the simplified big-leaf representation of the forest as a single surface".

Agreed and added this sentence: "it is important to recall that, when adopting the simplified big-leaf representation of the forest as a single surface"

Furthermore, I would call r_H the "apparent canopy aerodynamic resistance to heat transfer" (line 29) to indicate that this property is a construct of the formulation and not a direct physical property.

Agreed and modified accordingly. Also added the text: "the word apparent is used to indicate that this property is a construct of the formulation and not a direct physical property"

The entire roughness length formulation (eq 2-8 and table 1) is based on different variants of analytic approximation approaches to reduce the complexity of flow in and above the forest canopy to a 2-D-surface equivalent. It is widely accepted that as you go near the canopy, the MOST approach is not valid. It was proposed (and rather widely accepted) that a mixing length-driven approach can be applied (see Harman and Finnigan 2007, 2008 BLM). Nonetheless, large-scale models, which cannot vertically resolve the canopies, still use MOST and it has been demonstrated to be relatively accurate. My point here is that this section of the manuscript (eq1-8) should not be mixed with the notion that it explains the physics, but state very clearly that it revisits the current leading approach for simplification of the physics in a parameterized way that can be used by coarse-resolution models

Agreed. The following text is added to the end of the section 2.2:

"Before moving on to the usage of LES, it warrants mentioning that the entire roughness length formulation (equation 2 - 8 and table 1) is based on different variants of analytic approximation approaches to reduce the complexity of flow in and above the forest canopy to a 2-D-surface equivalent. It is widely accepted that the MOST approach is not completely accurate close to the canopy (Foken, 2006). It was proposed that a mixing length-driven approach can be applied (Harman and Finnigan, 2007). Nonetheless, large-scale models, which cannot vertically resolve the canopies, still use MOST and it has been demonstrated to be relatively accurate. Thus from an operational perspective, the present formulation revisits the current leading approach for simplification of the physics in a parameterized way that can be used by coarse-resolution models."

I think it will be beneficial for the manuscript if you emphasize the point that you are using an LES with an explicit 3-D canopy, where the surface assumptions are not needed to develop a revised approximation approach for the surface-equivalence that account to the forest density effects and parameterize for its outcomes in a way that will allow resolving the heat convector effect even in large-scale models.

Agreed and the following text is added in section 3: "It is worth highlighting again here that the large eddy simulations have been conducted with an explicit 3-D canopy. This means that the surface assumptions are not needed to develop a revised approximation approach for the surface-equivalence that accounts for the forest density effects. Only the outcomes of the LES are parameterized in a way that will allow resolving the canopy convector effect even in large-scale models".

P3 L26 "d is the zero-plane displacement height taken as 2/3h_c. . ." will be more correct to say: d is the zero-plane displacement height, often approximated as 2/3h_c. . . (and see study of roughness length and displacement height in a forest stand and their best approximation – Maurer et al Biogeosciences, 12, 2533–2548, 2015, and Maurer et al Agricultural and Forest Meteorology 177 (2013) 24– 34)

Agreed and modified accordingly. The references are added as well.

Technical corrections: I recommend setting an acronym for Rotenberg and Yakir (2010) - RY10, after the first use. It is listed so many ties that it gets rather tedious.

Agreed and changed accordingly.

Pg 2, L 32: "This 'canopy convector effect' is sufficiently efficient. . . Word placement is confusing. Can change "sufficiently efficient" to 'adequate enough', 'suitably efficient'

Agreed and changed to 'adequate enough'.

Pg 6, L 26: "while the output of first 6400 s. . ." change to "while the output of the first 6400 s"

Changed to "while the output of the first 6400 s"

Table 2 Please include the meaning of the Stability class (e.g. "Near-Neutral", Weakly Unstable". . .) as the first column of the table. Will make it easier to remember, and look up.

Added the meanings of the stability classes to the table.

Pg 9, L 6: "This description refers to a more general phenomenon as opposed to the the description. . .". Remove "the"

Removed the extra "the"

Pg 15, L21: Change to "These assumptions also lead to a less nonlinear height variation".

Changed to "These assumptions also lead to a less nonlinear height variation".