## Responses to the comments of the Referee #1

(The original comments are in **bold Arial**, the responses are in Times New Roman)

**This paper presents a very clever tilting of the calculation of sunlit and shaded leaf area from directly overhead to the direction of the beam of incoming light. I believe this is unique and that other attempts to model the penetration of light into the canopy look at horizontal planes. The inclusion of the code and a manual with its annotated input and output lists are exceedingly useful. However, as the manuscript is now written, it is somewhat inaccessible. It is difficult to follow the development of the model and I didn't understand the usefulness of the model until I got to the discussion section. I still don't understanding the testing of the model… Furthermore, the authors miss a few potentially exciting applications, see below. None of these problems are insurmountable or scientific in nature and I hope the authors will undertake to make their work more accessible through a well considered rewrite of the manuscript. Listed here are a few essential improvements.**

Response: Thanks for carefully reviewing the paper, including the equations. We clarified and added some parts in the text and added one more figure based on your suggestions and the comments from anonymous referee #2.

1. **Figures 5-8 show a comparison of the model with "the random approach". This is essential as it is the evidence that the model works. But I never understood what the random approach was other than a random placing of plants such that they don't overlap — what is the analytical solution of this that you refer to? And it seems the analytical solution is excellent, so be more explicit about why your model is needed.**

Response: We revised the second paragraph in section 2.4.1 into five steps to explain the random approach. The associated figure (Fig.4) was revised slightly as well. The random approach needs to run about 300 random cases to get a stable result and the computation takes a long time. Therefore it can be used to validate our model but is not efficient in computation. A similar explanation has been presented in the 4th paragraph in the discussion section.

2. **How is this model different from multi-layered canopy models (e.g. Mercado et al 2007, Tellus 59B, 553)? This is really important too for it explains why this work is useful and new. There is the start of a discussion of this in the Discussion section but it is not complete as it doesn't include the multi-layered models. Also, you need to elaborate a bit on the terms canopy models and individual-based radiation models. This discussion of the originality of this work needs to go in the introduction, and possible the abstract, as it sets the context of the work**

Response: Good point. We added one paragraph in the introduction section (the second last paragraph) about stand-based models and individual-based models and the purpose of IPR. We also added one section (section 3.2.3) and one new figure (Fig. 12) to directly compare between the results of IPR model and the two-big-leaf method. Some text was added in the methodology section as well (section 2.4.2) for the purpose of this comparison.

3. **And mention far earlier, perhaps in the abstract, that this code can be easily implemented into big-leaf models, etc etc and that the code and a users manual are available in the supplementary material along with a nice annotated list of inputs and outputs. This is great stuff! Advertise it!**

Response: One sentence was added in the abstract to indicate that the code and a user's manual are included with the paper.

**The authors miss out on some important applications of their work**

- **This model has the potential to improve modeling of savannahs in global dynamic vegetation models (e.g. Sitch et al 2003). Savannahs often behave differently from forests and grasslands in vegetation models and the current models struggle to capture this behavior**

Response: Parklands and savannah were added in addition to boreal and arctic ecotone for the possible applications of the model.

- **There are also applications to the diffuse fertilization effect which the authors have not mentioned and this further enhances the usefulness of their approach (e.g. Mercado et al 2009, Nature 458: 1014–1017).**

Response: We would like to focus on the model description and validations of the model in this paper. Further analysis and applications can be done later on.

**Finally, it was rather difficult to follow the line of reasoning in the paper.**

- **It was quite heavy going with all the equations. Could a large portion of them be relegated to the supplementary material and only the key setting up equations and the main ones used in the code be presented in the text?**

Response: We have thought about different options to put the equations in the paper (put the equations together as a table in the paper, or as an appendix or as supplementary material). In the current way, the equations are explained more thoroughly than other options.

**Consider making some kind of diagram, perhaps a flow chart, which documents your model's steps.**

Response: We thought about this but did not find a clear way to show it visually. So we added a paragraph about the road map of the model (the second paragraph in section 2.2).

- **It might help to provide a few sentences at the end of the introduction which state what the following sections are about**

Response: We added three sentences at the end of the introduction section about the structure of the paper. We also add a paragraph (the second paragraph in section 2.2) about the structure and the road map of the model.

- **The language standard is generally very high, but there are a number of places where it is impossible to discern the meaning.**

Response: We carefully polished the language and clarified some sentences of the paper.

**Specific comments**

- **"K0 is the light distinction coefficient" do you mean light extinction coefficient?**

Response: Yes and corrected.

- **"when leaves are distributed side by side" – what does that mean?**

Response: We deleted the sentence. Readers can find more explanation following the included reference.

- **Equation 5 – in the third expression F[1-exp(- k r l)] dA I don't think the dA should be there and therefor it should be in the denominator of the last expression dL K /dA**

Response: The latter part of the equation (dA = kdLb) was deleted.

- **In equation 8 – should the dz term also carry a contribution of cos theta to make that component perpendicular to the incoming solar radiation?**

Response: You are right. The *cosθ* in the equation is coming from the effects of the angle *θ*.

- **Is the symbol of an upside down U in equation 17 mean to be a capital Π? meaning multiplying all the terms in the series? You may wish to clarify the symbol and write out the meaning.**

Response: you are right, and an explanation was added.

- **Can you comment on the physical circumstances under which the 2-leaf model fails? I.e. at what LAIs?**

Response: see below.

- **It would be really nice to see the 2-leaf model on the same panel as your model…**

Response: We added a section (section 3.2.3) and a figure (Fig. 12 in the text or Fig. R1 below) to directly compare the results of IPR with that of the two-big-leaf method. The purpose of such comparison was indicated in section 2.4.2 as well. It shows that the two-big-leaf method significantly over-estimated the fraction of sunlit leaf area when plants are sparse, especially when the elevation of the sun is high as some light will directly reaches the ground through the gaps among crowns. The results of IPR and the two-bog-leaf method are very close when plants are dense.

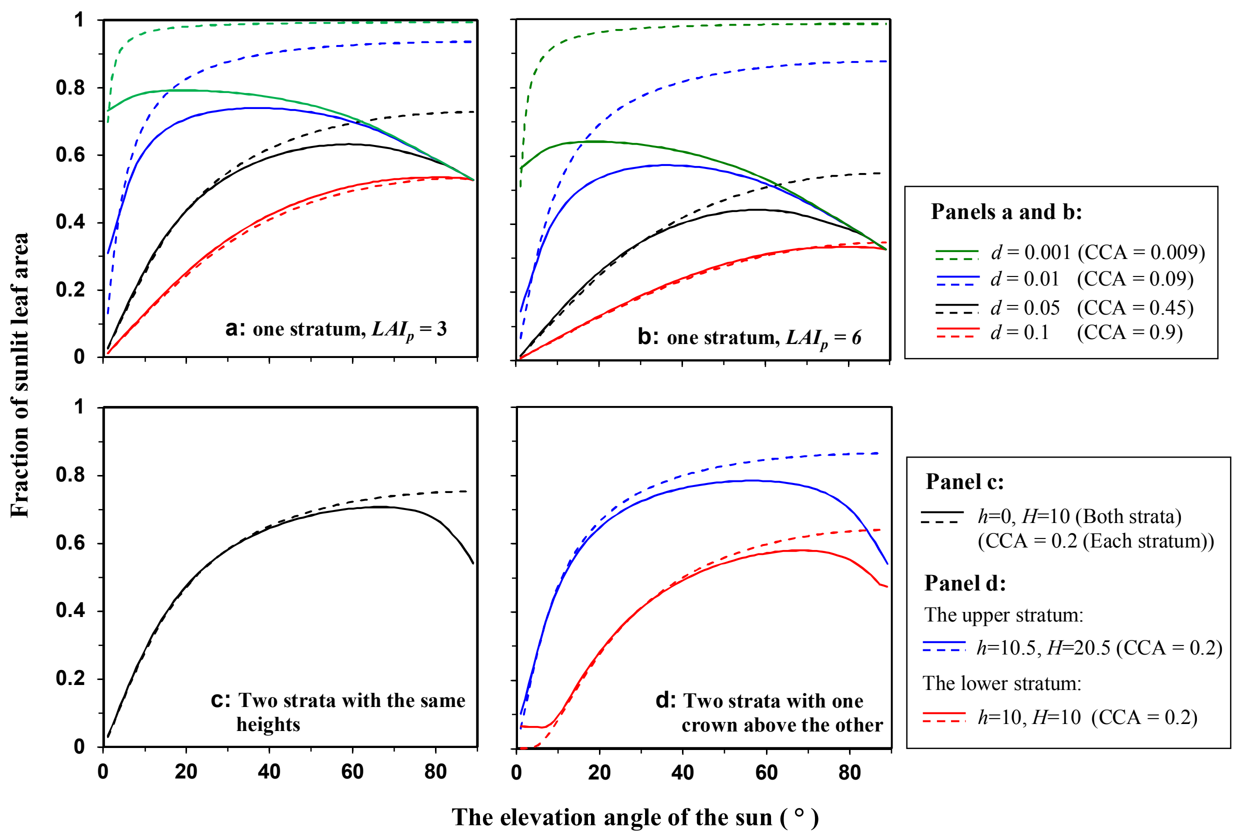


Figure R1. Comparisons of the calculated sunlit leaf area fractions between the IPR model (the solid curves) and the two-big-leaf method (the dash curves). Panels a and b are for one-stratum plant communities with different local leaf area index ($LAI_p$) and plant densities ($d$) (shown in each panel and the legend). The other parameters are the same: the bottom height of the crown $h$ = 0 m, the top height of the crown $H$ = 10 m, and crown width $D$ = 3 m. The fraction of crown covered area (CCA) can be calculated as $D^2 \cdot d$ and is also shown in the legend. Panel c and d are for two-stratum plant communities with the same crown heights and one crown above the other, respectively (crown heights and CCA are shown in the legend). The other crown parameters are the same: crown width $D$ = 1 m, local leaf area index $LAI_p$ = 3, and plant density $d$ = 0.2 plants/m$^2$. For the two-big-leaf method, the leaf area index of a stratum was calculated as $D^2 \cdot d \cdot LAI_p$.