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# *Interactive comment on* "Summertime canopy albedo is sensitive to forest thinning" *by* J. Otto et al.

**J. Otto et al.**

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Reply Reviewer #2

Thank you for your constructive comments. The review by referee 2 made us realise that we failed to precisely describe the focus of the manuscript. There are much more sophisticated 3D-radiation transfer models than the 1D model we use and we don't aim at advancing the field of vegetation remote sensing. For this, we agree that we used the wrong tools and experimental set-up. As large-scale modellers we strive understand the interactions between forest structure (driven by forest management) and find the minimal complexity needed to include the process under study in our large scale model. Our aim is therefore to present an approach that can be applied for different regions (using only a reduced number of input parameters) and can be adapted for inclusion in



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land surface models to enhance their capacity to simulate the regional or even globally effect of forest management on climate. We will revise the manuscript according to this and expect changes in at least the abstract, introduction and discussion to better reflect this.

Legend for uploaded pdf-file (bg-2013-357-supplement.pdf):

Page (1) and page (2) are about your question whether the relationship between LAI and tree height or canopy cover behaves linear or non-linear. Plotted is the mean LAI over the mean height (page 2: mean canopy cover) for all species and simulations The relationships are non-linear.

Page (3) and page (4) are about the question what is driving the changes in LAI. Shown is the effective LAI as a function of canopy shortwave albedo and the crown volume as function of canopy shortwave albedo. The figures show that the 'saw-like' pattern in albedo is not solely caused by changes in the effective LAI but rather by changes in the crown volume.

Page (5) and page (6) show effective LAI versus visible albedo and versus near-infrared albedo. In the visible range we see the effect of increasing LAI leads to decreasing LAI. The opposite effect is seen for the near-infrared range.

Comments:

'Modelling approach': Yes, you are right about the description. Two things are missing in the description: ForGEM simulates the forest management scenarios for a region of one hectare and we subdivide this area into 20x20m subplots to calculate the spatial variation in albedo. We use the 3D forest description from ForGEM for the "ray tracing approach" to calculate the fraction of light reaching unscattered the forest floor for a given solar angle. This fraction was then used as input in the inverted Beer-Lambert's law to derive the effective LAI.

'Table 1' and 'Page 15380': we will follow your advice and will show the effective LAI of each simulation.

'Study of how different thinning scenarios affect canopy albedo:' Yes, we use the effective LAI as input to the 1D radiation transfer model and we believe that as this single variable is effective, it is significant to be used in the radiation transfer scheme. In many publications Pinty et al. (e.g. 2006 and 2011) have shown that the values taken by the 1-D model variables characterising the vegetation canopy layer are effective in the sense that these values are derived from a 1-D homogeneous turbid medium model, i.e., the two-stream model, constrained to yield the same radiant fluxes as those that would be estimated from a 3-D heterogeneous canopy. They show that the effective LAI fully controls the fraction of absorbed light in the canopy. Thus we are convinced that the canopy structure is well reflected in our approach. ForGEM is a spatially explicit, individual tree model that models, individual tree height, tree diameter, sapwood and heartwood biomass, and crown volume. Contrary to the opinion of the reviewer, we think ForGEM is well suited to model the 3D canopy structure of a forest. The capacity of ForGEM in simulating the forest structure is demonstrated in the validation section. We combined measured canopy characteristics and a "ray tracing approach" to derive the effective LAI which we use in the radiative transfer model. The validation shows that our approach gives reasonable results. We will better stress this in the manuscript (L391-399). Furthermore, we attached two figures (page 1 and page 2) where we plotted the (true) mean LAI against mean tree height of each year and the same against mean canopy cover for each simulation. Although our approach is simple, the relationships show a non-linear behavior which shows that our approach can keep up with more sophisticated models.

'Single scattering albedo': Yes, the single scattering is constant throughout the stand development. In reality scattering properties change with stand age and structure but this effect is often neglected in modelling studies, see for example (Rautiainen et al., 2011)âĄă. Our focus is to develop an approach which can represent the relationship between changes in stand structure and canopy albedo but on the same time is appli-





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cable in land surface models. To find a compromise between a very realistic approach or an approach which is accurate but does not require a reduced number of input parameters, we decided to accept this simplification. We'll revise the manuscript to underline the purpose of this approach.

'Page 15380, section 5:' We use white-sky albedo for the comparison with observations and use black-sky albedo for the analysis, we'll add here an additional analysis for white-sky albedo. We'll revise the validation section.

'The simulated summertime canopy albedo:' Figure 3 shows the gap fraction (we will use coloured lines for better visibility) from the "ray tracing approach" which is a 3D model and thus it is a good comparison to check if we are in the range of the measured gap fraction.

'driven by tree species:' This means that at the beginning of the rotation the different species explain the difference in canopy albedo.

'Page 15386:' Every simulation was performed for 1 hectare (10,000 $m^2$) of forest with the 3D model ForGEM. This one hectare was divided in 25 squares (20 m x 20 m) and we use the effective LAI of each subplot to calculate the albedo for each square separately. We'll revise that in the manuscript.

'Page 15386, How does thinning:' Please see the attached figures on page 3 and 4 showing the effective LAI vs shortwave albedo and the crown volume vs shortwave albedo. The figures show that the 'saw-like' pattern in albedo is mainly caused by the changes in crown volume and not by changes in the effective LAI but rather by changes in the crown volume. For scenario (I) with an LAI of about 3 the albedo doesn't change anymore, the albedo value saturates. This effect is more dominate for beech and oak than for pine. 'Crown volume and LAI:' Please see our explanation above about the effective LAI. The changes in crown volume are indirectly an input parameter to the radiation transfer scheme.

'low LAIs correspond :' The effective LAI versus visible albedo (page 5) shows clearly the effect of decreasing LAI leads to increasing albedo. However, the opposite effect is seen for the near-infrared range which is prevails in the calculated mean of both ranges. This is not surprising, the scattering parameters are much larger in the near-infrared compared to the visible range so we would expect that increasing LAI leads to an increase in multiple scattering and an increase in canopy albedo.

References:


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Pinty, B., Lavergne, T., Dickinson, R. E., Widlowski, J.-L., Gobron, N. and Verstraete, M. M.: Simplifying the interaction of land surfaces with radiation for relating remote sensing products to climate models, J. Geophys. Res., 111(D2), 1–20, doi:10.1029/2005JD005952, 2006.

Rautiainen, M., Stenberg, P., Mottus, M. and Manninen, T.: Radiative transfer simulations link boreal forest structure and shortwave albedo, Boreal Environ. Res., 16(2), 91–100, 2011.


Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/10/C7714/2014/bgd-10-C7714-2014-supplement.pdf


Interactive comment on Biogeosciences Discuss., 10, 15373, 2013.