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

**Anonymous Referee #2**

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General comments

This manuscript presents a study on the impact of forest thinning on summertime canopy albedo. Three tree species and four different thinning scenarios were taken into account. The work strives to provide a deeper insight into timely and highly relevant topic of state-of-the art vegetation remote sensing - what is the relationship between forest structure (through different forest scenarios) and canopy albedo. The authors conclude, that more intensive thinning leads to lower summertime canopy albedo compared to unthinned forest. In my opinion, the manuscript possess several major shortcomings and generally lack the clarity in the description of applied methodology and interpretation of results. More specific comments follow.

Specific comments



page 15376, 1 Introduction, ’Of the main land surface types...trees generally have the lowest albedo’: what about inland water class - e.g. lakes, rivers. These are generally land surfaces with lowest summertime albedo values.

page 15378, 2.1 Modelling approach, There were two models used in the study - ForGEM as individual tree / stand model (outputs: tree height, crown volume, leaf mass, true leaf area index and spatial position of trees within stand) and 2stream - top-of-canopy albedo model (inputs: effective leaf area index, effective leaf single scattering albedo, effective scattering direction of vegetation, true background albedo). According to my understanding of your approach, you generated different stand development paths with leaf area index as a function of thinning scenario and stand age (ForGEM model). This all has been done on individual tree level - i.e. area of 20 x 20m. To match the spatial resolution of e.g. MODIS observations, you merged 25 different ’plots’ into single 500 x 500m plot and calculated effective LAI from this ’stand LAI’ using beer’s law approach. Next, effective LAI as the only variable was used as an input for 2stream model. Here the scattering properties of vegetation (both leaves and branches) and understory has been obtained from inversion of 2stream model against MODIS white-sky albedos with 1 km resolution. To obtain species-specific scattering properties, land cover map of dominant tree species with 1km resolution has been applied to select only areas, where beech, oak and pine dominated. Although species-specific, the spectral properties were very similar and constant throughout stand development.

My questions specific to methodological approach are:

- Table 1 seems to be highly redundant to me. For all tree species and all locations you applied the same thinning scenarios. Why would you need to present this repetitively in the form of table?

- Study of how different thinning scenarios affect canopy albedo uses only effective LAI as in input to 1D radiative transfer model. I believe that this is way too oversimplified approach. Are you really able to describe the effects of 'canopy structure' based on this single explanatory variable? Does the LAI increases linearly with canopy closure, proportion of understory visible for sensor, aboveground biomass, diameter at breast height, or tree height? How would you take into account different spatial arrangement of managed, compared to unmanaged forest stands. All of the above mentioned are non-linearly related to forest albedo, as presented before (Rautiainen, 2011, Lukeš et al., 2013).

- Single scattering albedo of vegetation has been derived above 1 km MODIS white sky albedo product. Whereas single scattering albedo of vegetation is around 0.7 in NIR, the understory albedo in NIR was between 0.1 and 0.3. In the model, vegetation albedo is composed of single scattering albedo of leaves/needles and branches (woody area) and is constant throughout the stand development. Once again, this is greatly over-simplified assumption. For coniferous stands, there are differences between different needle age classes and the proportion of different needle age classes changes from juvenile stands towards mature ones. For both coniferous and deciduous stands, the proportion of woody area changes as the stand grows. Moreover, we may expect, that unthinned forest would have higher abundance of branches and smaller living / total crown length ratio - i.e. different (perhaps lower) single scattering albedo of vegetation. Both stand age and thinning scenarios would therefore require its specific single scattering properties of vegetation.

- Page 15380, section 5, 'Thus, we use bi-hemispherical reflectance (BHR) assuming diffuse illumination, for the comparison with observed albedo values'. Do you mean white sky albedo, or blue-sky albedo here? Both black-sky (direct irradiance) and white sky (diffuse irradiance) albedos are theoretical concepts, which are not directly comparable to in-situ measurements of blue-sky (direct+diffuse irradiance) albedo. Please clarify.

- Page 15380, 2.2 Set-up of species-thinning experiment, Thinning experiment is propagated into 2stream model through changes in effective LAI values, right? It might be



more informative to publish these values instead of Table 1.

- Page 15382, 2.3 Validation

- 'The model chain, was validated against forest properties...' - I don't understand, please re-phrase. - 'each site is presented as the mean albedo of June (2001-2010) by MODIS' - what MODIS product and what albedo representation is used? Did you apply any quality flags to exclude magnitude BRDF inversions? - FORGEM should be ForGEM - Reference to in-situ pyranometer measurements is missing - The whole section is very confusing - did you use in-situ measured LAI data for forward simulations of black-sky albedos, which were then compared against MODIS observations and in-situ pyranometer readings? If so, why do you need to present such detailed forest structural parameters (e.g. tree positions, DBH, Tree height, Crown radius and Crown length)?

- page 15383-15385 3.1 Validation of the model chain

- 'The simulated summertime canopy albedo of deciduous forest lies within the range of the MODIS-observed albedo values' - we could have expected that, since all the model input parameters except the LAI were retrieved from MODIS white-sky albedo product. - Figure 3 - I can't really distinguish between different gap-fraction observations. Please change colours for better separability. - The presence of Figure 3 itself is questionable. Why do you present any gap-fraction data if 1D model is used to simulate canopy albedo? Or is there any other, more complex model involved to simulate forest albedo?

- Page 15385, 3.2 Attribution

- 'driven by tree species' - do you mean differences in the single scattering properties of vegetation and their effective LAI in initial development of stands?

- Page 15386, 3.3. How does species affect summertime canopy albedo? - 'Simulations were performed for 25 subplots of 20m x 20m, adding up to one hectare of forest' - I'm little bit lost here. How can you simulate 20m x 20m patches of forest in 1D representation of canopy? There's no mention of this in 2.1 Modelling approach. Do you mean that you used effective LAI value that has been calculated from ForGEM model for the area of 20m x 20m? There's obvious mismatch between the scales of different models here.

- page 15386, How does thinning affect the summertime canopy albedo? - Could you please plot effective LAI as a function of canopy albedo? It's likely, that the 'saw-like' patter in your albedo trends is caused solely by the changes in effective LAI. After each thinning, there's a decrease in both LAI and albedo. On the other hand, for birch and oak canopies without any thinning scenarios applied (scenario I), albedo is virtually constant and is not driven by LAI (which changes from two to seven, and four respectively). Please explain these results with regards to forest albedo model inputs.

- Page 15388, 3.6 what drives changes in summertime canopy albedo?

- 'Crown volume and LAI are positively correlated' - this is probably a function of ForGEM model, in canopy radiative transfer model we alter only effective LAI. The purpose of forest thinning is to increase diameter at breast height of the trees and their height, sapwood biomass. None of these are included in the model.

-'low LAIs correspond to low summertime canopy albedo' - although relationship between LAI and canopy albedo is complex and influenced by multiple aspects (e.g. canopy closure, understory reflectance), I would have expected that for most forest stands albedo would decrease with increasing LAI (Lukeš et al., 2013). With decreasing LAI, the multiple scattering processes within forest canopies decreases (see Rautiainen and Stenberg, 2005) and the contribution of forest-floor understory increases. Decrease in canopy albedo with decreasing LAI would be possible only with black-soil assumption, or for forest understory with very low albedos. This is not very realistic, since with decreasing LAI, the irradiance rates reaching forest floor will increase, thus supporting growth of green understory vegetation. Please explain.

- Page 15392, 4.2 the effects of forest thinning on summertime albedo - Second column



already discuss more the climate effects, I suggest to make it part of 4.3 Climate effects of thinning.

Reference cited:

Lukeš, P., Stenberg, P., Rautiainen, M., 2013, Relationship between forest density and albedo in the boreal zone, Ecological Modelling.

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