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Biogeosciences Discussions

Interactive comment on "Stand age and species composition effects on surface albedo in a mixedwood boreal forest" *by* Mohammad Abdul Halim et al.

Anonymous Referee #1

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General comments

This study investigates the effect of disturbance type (harvest, fire) on boreal forest albedo, based on in situ albedo measurements. The authors conclude that i) post-harvest albedo is higher than post-fire albedo, ii) albedo saturates at ∼50 years' age after both disturbance types (which is later than the authors expected: they expected saturation at ∼25 years' age or earlier), and iii) successional changes in species composition are a key driver of age-related patterns in albedo. I see high risk that the conclusions are not valid because:

1. The authors complement their data with data taken from previously published pa-

pers (which they call 'secondary sources'). When looking at those papers in detail it is noticed that they used pyranometers working at full range of the solar spectrum (from approx. 300 to 2800 nm), while the data collected by the authors is recorded at visible and near infrared spectral regions (300–1100 nm). This can result in substantial differences between the data sets. Another problem is that the effects that are seen may be due to differences in climate (particularly snow depth, snow properties, and extent of snow-covered period), rather than forest structure or species proportions. The most distant study site (Alaska) is thousands of kilometres away and located in different latitudes than the main study site (∼65°N compared to 49.55°N). Therefore, it is likely that not only climate, but also the forest structure (e.g. height, canopy closure) as function of age, differs notably from the forests measured by the authors.

2. The amount of data is relatively small (only 15 plots + those obtained from secondary sources). For example, the conclusion that wintertime post-harvest albedo is higher than wintertime post-fire albedo seems to be due to some post-harvest plots showing very high albedos. The variation in albedo among post-harvest plots is large (Figure 4a). Removing some of the post-harvest plots with high albedo would probably result in notably different conclusions. Another example is the conclusion that albedo saturates later than at 25 years' age (but at no later than 50 years' age). I think that it is impossible to make such conclusion, because there is no data measured for stands aged 20–50 years.

3. The error sources and quality control of the measurements are not described in detail enough. The highest summer- and wintertime forest albedos measured by the authors are towards the higher end of what has been reported earlier. This may be because of limited spectral range in the measurements (i.e. not a measurement error), but it is difficult to say for sure, because this is not discussed by the authors.

From 1 it follows that the secondary data sources are not comparable with the authors' measurements and should be left out. I appreciate value of in situ data and the effort that the authors have put in the experiment. It might be possible that the authors'

measurements alone would result in interesting conclusions. However, this is difficult to evaluate based on the data and figures presented. I provide specific comments below to help the authors improve their work.

Specific comments

L17-18: It would be useful to state which stand ages these values (63%, 24%) apply.

L21: It is not clear what is meant by “seasonal albedo”. I suggest defining the concept before its usage.

L21-23: I agree that change in species composition when the forest gets older is one driving factor of albedo changes. However, also the forest structure changes when the forest gets older. For example, increasing canopy closure reduces the visibility of ground surface, and increasing tree height/canopy closure increase the shadow fraction. These both reduce forest albedo. There is lots of empirical evidence (at least based on satellite albedo measurements) in literature suggesting that albedo of coniferous forest changes with stand age, even though the species composition does not change. Thus, I think that your statement here is too strong. Species composition is one driver of age-related albedo changes, but based on the data presented, I would not say that it is a “key driver”.

L34: It might be useful to clarify what is meant by “the relative stability of the atmospheric temperature profile”.

L70-72: I doubt that the legacy charcoal from fires that happened several years or decades ago would influence albedo at the time of harvest.

L73-75: This sentence is also a bit unclear. It needs more clarification how (through which physical mechanisms?) decomposition processes and plant colonization would influence albedo.

L96-97: The first hypothesis is a bit contradictory to what is stated on L65-68 (that post-harvest stands typically have higher proportion of broadleaved species). Large

proportion of broadleaved species should lead to higher albedo.

L105: I think it is important to explain (in qualitative, descriptive terms) what kind of structure do the post-fire stands have. Do they have lots of standing dead trees? How severe were the fires?

L107: It is not clear whether all three replicate plots were in separate stands or in the same stand?

L111-119: Would it be possible to show the forest structural variables for each study plot in a table? This way the reader would get better understanding of the forest structure and species composition and their development through stand age.

L117: What does the abbreviation LFH stand for?

L121-124: How was the placement of the albedo measurement towers? I guess that the stands were surrounded by older (higher) forests? How far from the stand edges the towers were placed? Did the surrounding forests block a portion of the incoming diffuse radiation and is there a possibility that this would have affected the measurements?

L122: Due to limited spectral range (300–1100 nm) the upper end of solar spectrum (from 1100 nm up to 4000 nm) is left out and therefore the measured albedo is not full shortwave albedo. I looked at the methods of the papers providing secondary data sources, and noticed that they used full solar spectrum: -Chambers and Chapin (2002), Liu et al. (2005): Eppley precision spectral pyranometer, 285–2800 nm -Amiro et al. (2006a): Kipp and Zonen CNR1, 305 to 2800 nm -Amiro et al. (2006b): Kipp and Zonen CM3, 305 to 2800 nm

L126-127: What kind of quality control procedures were applied in the data processing? The explanation in the manuscript gives an impression that data from all days were useful and no outliers etc. needed to be removed. Did you remove some observations/days due to low quality?

L131: “deciduous broadleaved area”. Does this refer to basal area, or something else?

L132-133: The diameter limit is much stricter than the height limit. Usually trees with 5 cm diameter at breast height have height at least $\sim$5 meters. This means that you do not need the height limit at all, because the diameter limit already excludes all trees with height less than 5 m. The diameter limit is also quite high considering the young age of the forests. I do not know exactly how fast the trees grow in the study area, but I would guess that forests with ages from 0 to 10 years have only few trees (if any) with diameter at breast height exceeding 5 cm. Is the high diameter limit the reason why some stands are missing in Figure 6 (that shows the albedo dependence on broadleaved proportion)?

L137-140: Which of the measurement years (2013-2017) were used in calculation of the age? Or did you treat each year as separate observation and thus the age differed depending on which year was used?

L143-153. How does the climate in the secondary sites (particularly snow depth, snow properties, extent of snow-covered period) differ from the site in Ontario? This is very important because if the climate differs markedly, then the observed differences between post-fire and post-harvest stands are not solely due to stand structure and species composition.

L165: "top-surface-specular-included (diffuse and direct) reflectance" is a bit awkward definition. If the reflectance values were measured with integrating sphere setup (collimated light used for illumination, and the reflected radiation collected over the hemisphere), then I would express it something like: "directional-hemispherical reflectance factor of the top-surface of the soil sample".

L169: Does "ten different locations" refer to ten different locations within the sample? How is a location defined (how large area is covered by one measurement)?

L169: What does "Boxcar width 5" mean? It needs more explanation.

L187-196: Are the selected model shapes based on physical nature of the phenomena

studied, or are they just chosen to give the best model fit to the observed data? For example, in Figure 6g it is difficult to imagine a physical reason why albedo would first increase as function of broadleaved percentage, and then decrease again as the broadleaved percentage approaches 100%.

L209-210: Variability of albedo in post-harvest stands in winter and springtime is indeed very high. For example, in Figure 4a it is seen that the albedos of the young forests (<50 years) vary from approx. 0.2 to almost 0.9. I think that 0.9 is very rarely observed except for pure snow surfaces with no vegetation. Are you sure that the variation is not caused by measurement errors? This is why I suggest reporting the details of your measurement and quality control procedure in detail. Another thing that caught my attention is the high albedo (approx. 0.3) of some stands in summertime (Figure 4c,d). Albedo values 0.2 (at solar noon) are rarely reported in boreal forests. Your values are approx. 50% higher than that. Is this because of the limited spectral range of the pyranometer?

Figures 2, 4–8: The number of observations varies between figures. It is not clear what constitutes an observation? There were 15 plots but the number of observations can be much higher than this. Is each year treated as a separate observation? Text on line 128 suggests this. If each year is treated as a separate observation, how does it affect/violate assumptions (independence of observations) in the statistical models?

Section 3.2: It might be possible to weight the observed ground spectra with incoming solar radiation, to calculate albedos of the ground surface. This way, it would be easier to link age-related changes in ground albedo to age-related changes in forest albedo.

Figure 6: Why Figure 6 does not contain all data presented in Figure 4 (high winter albedo values close to 0.9 are not presented in Figure 6)?

L254-255: Earlier (in Section 2.5) you state that only fall albedos were modelled with double-exponential model, but here you say that also summer albedo was modelled with double-exponential model. Which one is true?

L275: Please explain in more detail what is meant by “to avoid modelling complexities”. Does it mean that the model did not converge if it was too complex?

L287-288: I think word “dramatic” is too strong.

L290: I doubt that the conclusion that albedo saturates at 50 (rather than at $\sim$25) years' age is valid. You do not have any measurement data between 20-50 years (Figure 4).

L291: Please explain in more detail how you determine that the effect of broadleaved proportion is larger than the stand age effect?

L306-308: I think this sentence is a bit misleading. I would expect that from an energy balance perspective late spring is more important than winter, because the amount of incoming solar radiation is larger in late spring.

Technical corrections

L177-178: Near-infrared range must have a typo [700–100 nm].

L206-207: “post-harvest” repeated two times.

Table1: It is a bit difficult to see the difference between italic vs. regular font. Perhaps bold vs. regular would be a better choice?

L357: “albedo” repeated two times.

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