Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2018-501-AC2, 2019

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

Mohammad Abdul Halim et al.

abdul.halim@mail.utoronto.ca

Received and published: 14 February 2019

We thank Referee #2 for their critical comments.

Referee Comment 1: "I have several major concerns about the study methods that call to question these findings. My first and largest concern surrounds the extensive use of albedo data sourced from the literature (referred to as "secondary data") which are connected to sites located hundreds to thousands of kilometers away. Although the dominant species com- positions across sites may be similar, stand structure and other important site-specific attributes affecting the surface albedo may differ greatly across sites. These include differences in geology and soils (affecting albedo via their con-

Printer-friendly version

Discussion paper

trols over understory vegetation compositions, soil moisture retention, growth rates), differences in latitude (affecting the direct albedo component via differences in solar geometry), and – most importantly – differences in local climate (affecting albedo via controls over soil moisture, vegetation growth and phenology, length of snow season, and important snow physical attributes such as snow depths, snow age, snow water contents). Without controlling for differences in these important site-specific factors it is difficult to arrive at robust conclusions regarding albedo-age dynamics, albedo-species composition dynamics, albedo-canopy height dynamics, and albedo-ground cover dynamics. Regarding the albedo-age dynamic, for instance, asymptotes of the presented exponential models in Figure 4 seem to be heavily influenced by the "secondary" data comprising all data points beyond 19 years. Regarding the albedo-species composition dynamic, the "secondary" data points in Figure 6 for "Summer" and "Winter" seem to be heavily influencing the y-intercepts and thus affecting the model functional form and shape parameters. Secondary data points in Figure 7 also appear to heavily influence the model fits (or lack thereof) for the "Summer" albedo-canopy height dynamics."

Authors' Response 1: On the use of secondary albedo data Referee #1 has pointed out similar issues. For the sake of brevity, we are not repeating the same response here. Please see the "Comparability of albedo measured in the field and from secondary sources" section of the Response to Referee #1.

Referee Comment 2: "A second methodological concern which is also related to the augmentation of the in-situ sample with literature ("secondary") data is the difference in the definition of albedo. Much of the secondary albedo data are for a broader spectral range (e.g., 295-2800 nm) than what is measured in-situ at the authors' own study sites (i.e., 300-1100 nm). This is important given the high albedo of vegetation in spectra above 1000 nm and given the sensitivity of the shortwave near-infrared broad band (1300–2500 nm) to differences in boreal tree species (see Hovi et al. 2017, https://doi.org/10.14214/sf.7753)."

Authors' Response 2: Referee #2 emphasizes that as silicon pyranometers do not sense beyond 1100 nm, we are missing an important part of the vegetation albedo as boreal vegetation shows higher sensitivity in SWIR (1300–2500 nm) region. Boreal vegetation sensitivity in the SWIR region might be interesting for species identification based on their unique spectral signatures, but from an energy/albedo perspective vegetation albedo in this spectral region might not be as important. Firstly, there is low energy available in this region as water-vapour/aerosol related atmospheric absorption is very high in SWIR (1100–2500 nm). In winter, energy in the SWIR region is even lower, and the canopy is either leafless or a good portion it is covered with snow. Secondly, even in the growing season, depending on leaf water content, foliage absorption in SWIR and scattering in NIR regions are very high (Ceccato et al. 2000). So, it does not seem plausible that vegetation albedo in the SWIR region is a large part of the broadband albedo. Similarly, the contribution of understory vegetation in boreal forest reflectance was also found to be affecting mainly visible and NIR region (Rautiainen and Lukešd 2015). As noted in the response to Reviewer #1, simulation studies suggest a theoretical maximum deviation in albedo values between instruments based on thermopile vs. silicon pyranometers of $\sim$0.09, but this is typically < 0.05. Under field conditions even class 1 thermopile instruments show deviations of 5-7% (Stroeve et al 2005).

Referee #2 also referred to Hovi et al (2017), who report leaf-level reflectance/albedo measurements of some boreal conifer and broadleaf tree species. These measurements are important for modeling albedo using radiative transfer models in combination with other parameters such as leaf angle distribution and LAI, but leaf-level reflectance values alone do not represent stand-level vegetation albedo.

Additionally, the common species in our study plots are trembling aspen, jack pine, and black spruce. Results from Hovi et al (2017) indicate that among the species measured, leaves of trembling aspen, jack pine, and black spruce showed the least response in the SWIR region. In young (0-3 years) post-disturbance sites there were essentially no trees. So, we do not think vegetation albedo in the SWIR region is an

Printer-friendly version

Discussion paper

important source of error of silicon pyranometers in our study.

Referee Comment 3: “I also have some concern about the study’s scientific value, irrespective of my concerns about the methods. None of the three major findings listed above are novel and can be distilled from a diligent review of the boreal forest albedo literature (e.g., post-fire: Lyons et al. 2008; Randerson et al. 2006; Amiro et al. 2006b; Liu et al. 2005; Wang et al. 2016 → https://www.sciencedirect.com/science/article/pii/S0034425716300888 post-harvest: Kuusinen et al. 2016; Kuusinen et al. 2014; Bright et al. 2013; Hu et al. 2018 → https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018MS001403).”

Authors’ Response 3: We hope that Reviewer #2 is aware that we have cited most of the articles (except Hu et al. 2018) they have listed. We have also discussed the strengths and limitations of previous studies in boreal forests and formulated research questions for our study. A diligent reviewing of the listed article may have its own scientific merit, but of course is not equivalent to collection of new field data. None of the studies listed were designed to answer the specific questions for mixedwood boreal forests we have addressed in this study, and they were concentrated either on post-fire or post-harvest sites, not on both.

Reviewer #2 suggests that there are additional data from studies in post-fire stands; however, with the exceptions of Amiro et al. (2006b) and Liu et al. (2005), the studies cited are all based on satellite data, not ground-based measurements. Similarly, all suggested studies for post-harvest stands are based on satellite data. Satellite-based albedo measurements often show biases due to atmospheric effects and angular corrections (Bright et al 2015). Due to limitations of satellite-based measurements, it is very important to have field measurements and to validate process-based hypotheses from field data.

Among the studies listed, Randerson et al. (2006), Lyons et al (2008), and Liu et al. (2005) are from the same study area, and essentially use the similar dataset to answer different questions. Amiro et al (2006b) is the only study that presents long-term (>1 year) field data in post-fire stands. Prior field studies are also mostly limited to the summer and winter seasons, and do not present shoulder season data.

Given that we are using long-term (2013-2017) field data from both post-harvest and post-fire boreal mixedwood stands to answer specific questions, we strongly disagree with Referee #2's statement that results presented in this study are not novel. The main published study that has integrated post-disturbance data on albedo in boreal forests is that of Amiro et al. (2006), which integrates data from 22 sites and ∼37 site-years of measurements. The new data presented here are from 15 instrumented sites each monitored for 4 years, so 60 site-years of measurements, all in mixedwood boreal forests that the most important forest from a forest management perspective, but for which there are almost no prior albedo measurements.

To reiterate the main novel points of the study: i) Winter and spring albedo values are substantially higher in post-harvest than in post-fire stands.

ii) Post-disturbance patterns of recovery in albedo in boreal mixedwood stands are strongly influenced by changes in species composition.

iii) Differences in species composition were a more important driver of albedo than stand-age-related differences in boreal mixedwood stands.

iv) There are important stand-age-related dynamics in albedo in the first 15 years following disturbance events that have been "missed" by prior studies.

Referee Comment 4: "Further, the study is motivated by the need to "improve climate model parameterizations" but the authors have made no attempt to explain how their results can/will achieve this. How will the presented statistical functions or empirical insights be applied in a climate modeling context, either for improving existing parameterizations in a climate model directly or for use as a climate model benchmarking/evaluation tool? Albedo parameterizations in most climate models are process-

Printer-friendly version

Discussion paper

oriented and intimately tied to important forest structural attributes like leaf area index which the authors have not included. Model parameterizations are also largely oriented around important local meteorological state variables (i.e., near surface air temperatures, wind speeds, precipitation type and frequency, snow depth, etc.) which are absent in the paper. This makes it difficult to discern the conditions under which the reported findings may be applied to evaluate climate model predictions. Further, since the reported albedo dynamics for the post-harvest case are intimately connected to the specific management practices of the study region, without providing any detail about the prevailing management regime(s) of the study region it will be difficult for modelers to assess accuracy of simulated post-harvest albedo dynamics. As for the post-fire case, the finding that the near-term (< 25 yr) increases in summertime albedo are connected to pioneer birch succession (a finding reported in several of the references listed above) implies that any "improvement" to the albedo prediction capability of a climate model would need to target the vegetation dynamics routines of the model and not necessarily the "albedo parameterization" itself."

Response 4: The main "motivating statement" in the paper (in the last paragraph of the introduction) reads as follows: "Deeper understanding of the local mechanisms that account for variation in albedo will not only enhance global climate models (for example, via improving the land-surface model: Bright et al., 2018), but also help to design climate-friendly silvicultural practices (Astrup et al., 2018; Bright et al., 2015a; Matthies and Valsta, 2016)." We thus think the reviewer somewhat mis-characterizes the stated motivation, which is not climate model parameterization. We will further emphasize the inclusion of vegetation dynamics in the land surface model to improve albedo prediction in our revised manuscript.

References:

Bright, R. M., Myhre, G., Astrup, R., Antón-Fernández, C. and Strømman, A. H.: Radiative forcing bias of simulated surface albedo modifications linked to forest cover changes at northern latitudes, Biogeosciences, 12(7), 2195–2205, doi:10.5194/bg-12-

2195-2015, 2015.

Ceccato P., Flasse S., Tarantola S., Jacquemoud S., Grégoire J. M.: Detecting vegetation leaf water content using reflectance in the optical domain. Remote Sensing of Environment 77: 22-33, 2001.

Francois, C., Ottle, C., Olioso, A., Prevot, L., Bruguier, N., and Ducros, Y.: Conversion of 400–1100 nm vegetation albedo measurements into total shortwave broadband albedo using a canopy radiative transfer model. Agronomie 22: 611–618, DOI: 10.1051/agro:2002033, 2002.

Liu, H., Randerson, J.T., Lindfors, J., Chapin, F.S.: Changes in the surface energy budget after fire in boreal ecosystems of interior Alaska: An annual perspective. Journal of Geophysical Research 110, https://doi.org/10.1029/2004JD005158, 2005.

Rautiainen, M. and Lukešd, P.: Spectral contribution of understory to forest reflectance in a boreal site: an analysis of EO-1 Hyperion data. Remote Sensing of the Environment 171: 98–104, 2015.

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-501, 2019.