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Biogeosciences Discussions

Interactive comment on "Accounting for multiple forcing factors and product substitution enforces the cooling effect of boreal forests" *by* Eero Nikinmaa et al.

Anonymous Referee #2

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Review of Nikinmaa et al Biogeosciences

The goal of this paper is to make a more holistic evaluation of the net climate effects of Finnish boreal forests by adding secondary organic aerosols and product substitution to more traditional assessments including carbon and albedo, with radiative forcing as the metric. The study examines different management intensities and tree species under current and future climate scenarios. Overall, it is an interesting and extremely ambitious undertaking, and a logical and meritorious next step in the climate/land use literature. The authors have made good efforts to use the most regionally-specific methodologies. Unfortunately, the problem with such an ambitious analysis is that each

section essentially requires the level of detail of a full manuscript in order to be appropriately detailed. To condense the methodology, the authors heavily leverage prior work through frequent use of citations, and subsequently skimp on critical methodological details, making it impossible for the reviewer (or potential readers) to make accurate assessments of the methods. I think this is a fatal overall flaw of the manuscript, along with a few others I will review below.

Major issues

For the stand level assessment, the use of bare ground as a control is inappropriate. From the first sentence of the abstract, the goal of the paper is to examine the "climate change mitigating effect of boreal forest management". The appropriate control case is then whatever the natural land cover type would exist in the absence of management (e.g. climax unmanaged boreal forest).

As stated earlier, the inclusion of SOA is an obvious and important next step for this type of work, but unfortunately I simply do not believe the science is mature enough to be able to accurately represent reality in this sort of simplified column-wise treatment. If the uncertainty were properly handled and propagated through all the steps (which, critically, it is not here), then the large uncertainty would render the whole exercise moot. I'm extremely dubious about the methodology under a current climate, let alone under future climate with likely very different atmospheric chemistry. The assumptions that have to made are so numerous and crude that I think it renders the exercise meaningless. I think the only way to even attempt it is with a fully coupled GCM with MEGAN and online atmospheric chemistry etc., where many scenarios can be evaluated and error bounds generated. Furthermore, carbon and albedo can be more easily handed in the column-wise radiative forcing framework because we assume CO2 is well mixed, and albedo RF essentially operates in 1D. But SOA formation (and evapotranspiration, for that matter) produce an RF in a very nonlinear and very 3D way in the atmospheric fluid flow in a complex interaction with clouds (in the indirect forcing case), and are not well mixed, and are thus not completely attributable to the forest processes themselves.

For these reasons I think SOA may remain a fundamentally difficult if not impossible problem to address using the 1D radiative forcing framework.

As I mentioned earlier, error and certainty is handled crudely. In several sections uncertainty ranges are mentioned, but it's not clear that these are propagated through the analysis.

It's not clear to me how the stand level and regional level analysis are different, necessary, and what we learn from doing both. The assumptions in the regional level analysis seem better, but I have serious concerns about the albedo data for that section.

Regarding albedo data, is it really possible to develop species specific albedo functions from MODIS data? Why is the result a step function? How do these values compare to those of Bright et al., (2014)? Impossible to properly evaluate without presenting these data as a figure.

The section starting on line 157 about how future climate scenarios is very confusing and impossible to follow.

Regarding the decision not to include product substitution in year 2050 because technology will change too much: to me I feel the same way about the SOA predictions for year 2050 because there is both uncertainty in the methodology and the future emission and atmospheric chemistry such that it is intractable.

Minor comments The abbreviation A for albedo is confusing since it is a commonly used letter. Perhaps alpha?

Reference Bright, R.M., Antón-Fernández, C., Astrup, R. and Strømman, A.H., 2014. Empirical models of albedo transitions in managed boreal forests: analysis of performance and transportability. Canadian Journal of Forest Research, 45(2), pp.195-206.

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