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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Direct effect of aerosols on solar radiation and gross primary production in boreal and hemiboreal forests" *by* Ekaterina Ezhova et al.

Anonymous Referee #1

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The manuscript by Ezhova et al. estimates the impact of aerosols on solar radiation and GPP in five boreal ecosystems. This estimate is obtained from an analysis of data sets from these sites including information on GPP and direct and diffuse radiation as well as measured aerosol abundance (as particle number-size distributions). The authors find varying differences in the steepness of the response curves of GPP to diffuse fraction and optimum ecosystem responses at intermediate levels of diffuse radiation, meaning that enhanced aerosol load on clear days will give a positive response in GPP.

The subject of this study is highly relevant and interesting for ACP, and the data gathered and approach chosen by the authors provide a good basis for the study. However,

the analysis is sometimes hard to follow and difficult to judge, not least because the methods are described only very concisely and are largely intertwined with the results in sections 3 and 4. Moreover, the results are to some extent discussed in relation to sources of uncertainty, but there is little comparison of the authors' findings with other studies investigating aerosol effects on diffuse radiation or diffuse radiation effects on GPP. I would advise to improve and gather the description of the methods in a separate section, which would aid the reader in understanding the study, and to extend the comparison of the results in section 5 (or in a separate section) with other studies.

Apart from that, I have some concerns about the current analysis that would require more explanation from the authors. I provide my comments below, and would like to encourage the authors to improve the manuscript, as its results are very interesting for the research community.

Major remarks:

- The study lacks a Materials and Methods section. Section 2 provides basic information about the sites and table 1 provides a very concise summary of the variables that were used in the analysis, but the description of the data sets should be extended to be comprehensive. Please add basic information about the instrumentation used or references to papers that describe this, gaps/missing data in the data sets and possible gap-filling if applied. Also, many parts in sections 3 and 4 belong in a Materials and Methods section rather than in the Results: section 3.1 up to p. 5, l. 25, section 3.2 up to p. 7 l. 13 and p. 7 l. 22-25, section 3.3 up to p. 8, l. 24, section 4.1 up to p. 10, l. 23. Finally, sections 3 and 4 use more variables than table 1 does, sometimes with a concise description of their sources. I would suggest to add these (e.g., AOD700 and precipitable water (p. 5, l. 5)) also to the Materials and Methods section.

- Figure 2 and Solis modelling: The model result (Fig. 2b) does not seem to account for the cloudiness (magnitudes are roughly similar between Fig. 2a and Fig. 2b), is the model result here that of a clear day? Have the optical depths in Eq. 2 and 3 been

adjusted to the actual measured values? Or is this intentional and meant only to show that values at or above the clear-sky expected value can be found even at cloudy days?

- p. 7, l. 16: How is this number determined? Which measurements were used for this, which time of year, etc?

- p. 9, l. 3: I do not agree with the "observed ... increase in Rd/Rg with increasing CS": The model seems indeed to show this, but the three sites with observations show a huge spread and no clear correlations. Please test statistically whether there is a relationship between Rd/Rg and CS - I have clear doubts about that. See also the low correlation coefficients (l. 12-14) - R2 values are extremely low, so I guess that these results are not significant.

- p. 10, l. 13: Where does the 0.8 in the absorption come from? This number depends on (amongst others) LAI. Later, the LAI is used as an argument for differences in LUE, whereas I would rather assume that it affects PARabs.

- p. 11, l. 3: Where does the slope of 1130 W m-2 and its uncertainty (5%) come from? In figure 7, PAR is given in umol m-2 s-1, has this been converted?

- Fig. 8 and p. 11, l. 15: The optimum curves are very interesting, but where are the data in these curves? It would be interesting to see how well these curves can capture the actual observations, rather than only using the two linear relationships obtained from the observations before. It would also give an impression of how uncertainties propagate, and it may even be interesting to apply the same separation between clear and cloudy days as done in Fig. 3 and 5 to show how well these relationships work for each of the two types.

- p. 11, l. 17: For interpreting the GPP curves with the aerosol data, it should be noted that the aerosol analysis in section 3 has focused on clear days with conditions of Rd/Rg < 0.25, whereas the GPP analysis focuses on the entire range (including clouds). Please acknowledge this in the discussion of the results: The discussed vari-

ations in CS (l. 18) are all for clear days only.

- p. 12, l. 18: Why is such a low positioning of the optimum not feasible for these latitudes? This would simply mean that the decreasing PAR has a stronger impact than the increasing diffuse fraction with more aerosols, right?

Minor remarks:

p. 4, l. 18: Please explain what Aeronet sites are, or generalize the statement about availability of data from nearby sites.

p. 7, l. 4: Please provide a reference for the wavelengths that are affected.

p. 7, l. 5-10: This paragraph is hard to follow. If I understand it correctly, the authors want to state that aerosols interact more pronouncedly with PAR wavelengths (400-700 nm - the range could be mentioned to clarify the sentence) than with NIR wavelengths, so that the amount of diffuse PAR is relatively larger than diffuse global radiation or diffuse NIR. Correct?

p. 7, l. 18: I miss the logic in this sentence: Why are wavelength-sensitive interactions more pronounced with lower amounts of diffuse radiation?

p. 7, l. 29: You could replace x and f(x) in the equation with the respective parameters (fdifbb and fdifPAR/fdif)

p. 7, l. 31: Please add unit of the PAR quantum efficiency.

p. 8, l. 25: replace "is" by "are"

p. 9, l. 9: Please provide a reference for the low scattering for CS<0.005 s-1.

p. 10, l. 23: Where does the "increase or decrease" come from? Generally, lower light levels would give a relatively better usage of the light because saturation is not reached (meaning a higher LUE). Are there conditions where you would expect a decrease instead?

p. 12, l. 1: Is this analysis of forest fire impact shown anywhere? Fig. 7 does not separate between forest fire and non-forest fire days.

p. 13, l. 9: Why can AOD not be used for estimating the feedback loop?

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