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Comment on acp-2021-863

Anonymous Referee #2

Referee comment on "Canadian and Alaskan wildfire smoke particle properties, their evolution, and controlling factors, from satellite observations" by Katherine T. Junghenn Noyes et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-863-RC2, 2021

The paper presents an analysis of retrieved smoke particle properties made from the MISR space-based instrument aboard the NASA Terra spacecraft. Smoke plumes are identified over Alaska and Canada in the MISR data and correlated with (where available) fire radiative power measurements from the MODIS instrument onboard the same platform. Information on the smoke plume altitude is retrieved from the MISR stereo camera capabilities. Smoke plume altitude and particle properties from the MISR research algorithm (RA) retrievals are correlated with IGBP land types. Aerosol properties and loading are also correlated with drought indices.

The main conclusions of the paper are:

- Forest fire plumes tend to produce higher aerosol optical depth (AOD) and larger and less absorbing particles than fires from grasslands
- Aging of smoke particle is different between grassland fires and forest and woody fires, with the latter group exhibiting evident particle growth and a more rapid transition toward lower absorption in particles
- Drought is also a factor in smoke particle properties, with woody fires especially exhibiting a tendency toward decreased absorption in the particles as drought index is more severe.

The MISR instrument and products provide invaluable information on the distributions and properties of aerosols, and I think this paper (and subsequent analyses in other regions) could make a significant contribution to our understanding and characterizing the properties of smoke aerosols and their evolution near fire sources. That said, I am unclear on some implications of the retrieval assumptions that I think warrant further discussion, so I am suggesting major revisions.

Major Comments

I am unclear on how actually the plumes are selected from the totality of the MISR dataset. It isn't clearly articulated the criteria. Evidently 50% of the selected plumes are from the MISR plume height archive. Where are the other 50% from? Is the selection done manually? How? Line 230 states "Well-defined plumes…were favored for this analysis." What constitutes well-defined (AOD, something else)? Is it a requirement that it is a smoke plume versus something else? How are you certain you are selecting smoke cases? Are fire anomalies required? I think this needs to be in section 2.2, which rather than providing the information on case selection the title suggests seems more to be about the characteristics of the cases.

The main concern I have is that I don't know how to judge the robustness of the retrieval results regarding particle composition presented. My understanding of an algorithm like MISR's RA is that a "best" mixture is determined from its closeness to the observed spectral and angular data. I'm not clear on the orthogonality of the individual components in Table 1, and neither am I clear on how a mixture of these components that minimizes the cost function compares to another mixture that almost minimizes the cost function. Is there degeneracy in the results that admits a different solution? Is it significantly different? Some further presentation of such an error analysis would be important here in order enhance the confidence in the results presented.

I find the arrows in Figures 8 and 9 not very well justified and suggest they be omitted. If the point is there are clear trends then just plot the line fits with the appropriate statistics, otherwise I think the interpretation is a bit forced.

Minor Comments

Line 54-55: I think a comment here on pyroCb would be useful to add, to acknowledge the growing interest in this type of fire.

Table 1: For the utility of modelers, please include in the supplement further information on the particle properties summarized here. For example, the mode radius and width and the refractive indices at the MISR channels.

Line 91-96: This construct is unclear. Do you mean in the end that you consider new particle formation and condensation/hygroscopic growth as the distinct aging mechanisms?

Line 103: "Most current transport and climate models…" I think it is more accurate to say that most current climate models do not at present incorporate brown carbon at all. The treatment of smoke as being a mixture of black carbon, organic (white) carbon, and sulfates leads to I think what you mean by "BlS" in this paper.

Line 234: You mean the lower 48 here, as Alaska is part of your domain and is part of the US.

Line 293: 0.667 degrees is inconsistent with 0.625 degrees a few lines earlier. I believe the MERRA-2 fields are uniformly available on the 0.625 x 0.5 degree grid.

Line 327: "event" not "even"

Line 449: should be “compared to G”

Line 449/450: “More on particle properties in subsequent sections” seems a bit informal. Maybe “More information on particle properties is presented in subsequent sections.”

Line 461: Add pointer to Table 4 in this first sentence.

Line 467: Suggest starting a new paragraph with “To help interpret ANG…”

Line 476: Add reference to Figure 3 in this sentence that begins “As expected…”

Line 480: Add reference to Table 4 here again.

Line 587: I think “BlS” is meant instead of “BrS”