

Atmos. Chem. Phys. Discuss., referee comment RC2  
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## Comment on acp-2021-971

Anonymous Referee #2

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Referee comment on "The characterization of long-range transported North American biomass burning plumes: what can a multi-wavelength Mie–Raman-polarization-fluorescence lidar provide?" by Qiaoyun Hu et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-971-RC2>, 2022

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The paper discusses interesting measurements of aged biomass burning smoke with a unique lidar. The paper is well written and appropriate for ACP. The measurements are performed with a recently introduced advanced lidar that combines multiwavelength lidar, Raman lidar, polarization lidar, and (new!) fluorescence lidar techniques.

Minor revisions are necessary.

p3, l75: When discussing INP, please keep in mind that these aged smoke particles are organic aerosol particles, the organic properties (of humic-like substances) count, and not the ones for soot or fly ash. Therefore, Knopf et al. 2018 .... is appropriate as reference.

Knopf, D. A., Alpert, P. A., and Wang, B.: The role of organic aerosol in atmospheric ice nucleation: a review, ACS Earth and Space Chemistry, 2, 168–202, <https://doi.org/10.1021/acsearthspacechem.7b00120>, 2018.

p4, l96: One may cite Baars et al., 2021

Baars, H., et al. (2021). Californian wildfire smoke over Europe: A first example of the aerosol observing capabilities of Aeolus compared to ground-based lidar. Geophysical Research Letters, 48, e2020GL092194. <https://doi.org/10.1029/2020GL092194>

p4, l105: Please use 'pyroCb' instead of 'pyCb'!

p4, l112: Figure 1(b) is mentioned, and then (l114) Figure 3 is mentioned. Figure 2 is left out.

p5, l126: No one should introduce Figure 2!

p5, l128: AE decreased...

p5, l133: To my understanding, Cimel (AERONET) is unable to correctly measure AODs > 4.0. And now we have peak AODs of 5.8!

The Case study section is a bit boring, one should better emphasize the deviation of the optical properties on 17-18 Sep 2020 in Figure 5 from the rest, to make the entire story more exciting.

#### Section 4: Discussion

I miss a clear structure of this section. The discussion could be shortened and should clearly highlight the added value now available in terms of the fluorescence information. Please state clearly: What is new! The discussion should be some kind of a review of the recent Veselovskii papers 2020 (general method), 2021 (on pollen) and the recent one on smoke/cirrus observations (also submitted in 2021) together with the present article on North American smoke.

I would leave out any speculation. For example, the discussion on age of smoke as a function of height. This is just speculation, and usually depends on many different factors such meteorological conditions, fire type, burning material, size of burning area and so on....).

Some suggestions that should be considered. The smoke particles are usually glassy in the upper troposphere and stratosphere (see the review article of Knopf et al.) The organic coating means that the INP properties are controlled by organic (humic-like) material. When discussing heterogeneous ice formation, do not restrict yourself to mixed phase clouds and temperatures higher than -35C. Heterogeneous ice nucleation also occurs at -50 to -70C (in cirrus). All this should be mentioned.

Furthermore, PLDR (or better, ... the shape properties) seem to depend on relative

humidity (availability of water vapor) and further gases that can condense on smoke particles to make them spherical. And the concentration of the gases are high in the lower troposphere and then obviously decrease with height from the middle to the dry upper troposphere and the extremely dry stratosphere.

page 9, line 267-274: I would leave out such a discussion.

page 9, line 275-280, please state clearly how you calculate the lidar ratio, You cannot combine extinction and backscatter values obtained with DIFFERENT smoothing lengths.

page 9, line 287 to page 10, line 297: I would leave this discussion out as well. The paper deals with fluorescence. Please clearly state what is new...! Provide clear facts, what the added value is!

An extra section 4.2 on BBA as INP is not needed in this fluorescence-related paper. A paragraph on the impact of smoke serving as INP is sufficient, but please cover the full range of clouds from mixed phase clouds to cirrus (-25C to -70C), and then a reference to the recent Veselovskii paper on smoke-cirrus interaction is needed.

Veselovskii, I., Hu, Q., Ansmann, A., Goloub, P., Podvin, T., and Korenskiy, M.: Fluorescence lidar observations of wildfire smoke inside cirrus: A contribution to smoke-cirrus – interaction research, *Atmos. Chem. Phys. Discuss.* [preprint], <https://doi.org/10.5194/acp-2021-1017>, in review, 2021.

The conclusion section should finally also be better organized and structured. I do not agree that the fluorescence information is the better information to identify smoke. It is an additional one, more precise, another independent one, besides all the useful information on PLDR spectrum and lidar ratio spectrum.

Figure 3: mixed-phase cloud at 10 km height? Impossible!

Figure 4: All axis text must be enlarged, ... is much too small at the moment.

Figure 5: (d) Y-axis EAE/BAE is confusing, better write ... EAE, BAE. In the caption, please explain explicitly which intense parameters are shown. What does P1-P9 mean? Please state that P1-P9 are listed in Table 1....

Figure 7: Again, all axis text must be enlarged, much too small at the moment.

Figure 8: I would recommend to explain clearly what parameters are shown. Figures should be widely self-explaining.

Figure 9: Again, all axis text must be enlarged, much too small at the moment.

Figure 10: Here one could then state: Same as Figure 8, except.....

Figure 11: Again, what is shown... should be stated.

Regarding all the figures, keep in mind that many readers may not be lidar specialists and need a lot of information.