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Comment on acp-2021-846

Anonymous Referee #2

Referee comment on "Vertical structure of biomass burning aerosol transported over the southeast Atlantic Ocean" by Harshvardhan Harshvardhan et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-846-RC2, 2022

The paper presents averaged profiles of extinction, backscatter Angstrom exponent, aerosol depolarization and aerosol lidar ratio of biomass burning smoke as measured with an HSRL-2, as well as HSRL-2 retrievals of aerosol submicron fraction and the size of the sub-micron fraction, from the ORACLES project 2016 field deployment in the SE Atlantic. Data are aggregated into two pairs of 2degree x 2degree gridboxes, with one gridbox downwind of the other. An additional gridbox is included south of the biomass burning plume for contrast. The average properties of the aerosol, dominated by biomass burning smoke, are shown to be relatively invariant in the approximately 1day+ of transport from the upwind to the downwind gridbox.

The study is limited in scope but of scientific value and appropriately short. I don't have any significant problems with the analysis presented and think it's a solid and useful piece of evidence that the aerosol intensive properties measured don't vary significantly over a fairly broad region of the SE Atlantic. I do think the paper needs to be more carefully written. As such, I recommend publication after the many smaller issues below are addressed.

Smaller comments:

Abstract, pg 1, lines 20-21: "The fraction of aerosol in the fine mode between 50 and 500 nm remained above 0.95 and the effective radius of this fine mode was 0.16 um from 3 to 5 km in altitude." The wording here could use some work, and it would be better to stick to either nm or um. E.g: "In the 3-5km altitude range, 95% of the aerosol mass (is mass correct?) was in the 50-500nm radius size range, with the aerosol in this size range having an average effective radius of 160nm"

Pg. 2, line 28-29: "Aerosols are often considered as the most confounding element in the

climate system when simulating future parameters of Earth's climate." This isn't accurate. Aerosols are the most uncertain climate forcer in present day, as stated a few sentences later, but other things introduce much greater uncertainty in future climate. E.g. future GHG emission trajectories, cloud feedbacks and how climate warming might affect natural carbon sources and sinks are greater uncertainties in future climate projections than are aerosols.

Pg 2, line 38: "overly" to "overylay"

Pg 2, lines 46-47: "by mostly absorbing the incoming solar radiation" This isn't correct; the single-scatter albedo of these aerosols is ~0.85, so they scatter much more sunlight than they absorb.

Pg 2: In discussing the aerosol mixing into clouds, there are at least two studies from ORACLES that could be cited: Diamond et al. (2018) https://doi.org/10.5194/acp-18-14623-2018 and Gupta et al. (2021) https://doi.org/10.5194/acp-2021-677

Pg. 4, line 108: "at the grid box center" Do you mean that arrived within the 2degx2deg gridbox? This reads as if it only includes those data points that exactly fall at the gridbox center. Is this the case?

Pg 4, line 121: I'm not sure what the use of the word "tenuous" here is intended to mean.

Pg 5, line 153: "Aerosol extinction… the primary measure of aerosol abundance". Aerosol mass or number concentration is the primary measure of aerosol abundance (depending on what question you're trying to answer). Extinction depends on mass, size and relative humidity. The role of relative humidity in determining extinction needs to be acknowledged. Two articles that address the role of humidity in the context of aerosol extinction from the ORACLES campaign and that could be referenced are Pistone et al. (2021; https://doi.org/10.5194/acp-21-9643-2021) and Doherty et al. (2022; https://doi.org/10.5194/acp-22-1-202)

Pg. 6, line 171: "essentially constant extinction from just above 2.5 km to 5 km" For box B, the extinction is a bit more variable so I'd reword this slightly to "relatively constant extinction"

Pg. 6 lines 171-187 The discussion here needs to reference the figures in the appropriate places.

Pg. 6, lines 174-177: "The Lidar Ratio above 3 km … is considerably less and highly variable in Box E and in the lower layers of the aerosol plume in Box D, where the plume most likely has components of continental aerosol typical of the nearby Namibian coast." What is the basis for assuming that the lower part of the plume in Box D is "continental aerosol"? And what does "continental aerosol" mean? Dust? Pollution? A mix of BB smoke, dust and pollution?

Pg. 6, lines 177-179: "The most striking feature of the results are the near constant values of these parameters in the upper two kilometers of the plume over the course of several days as evident from the range of values in the 25-75 percentile shaded grey in Figs. 6 and 7."

The text right before this was discussing the lidar ratio, but the lidar ratio is shown in Figure 8 so its not clear what "these parameters" is referring to?

Also, this text is a bit ambiguous. It can be read to mean that "these parameters'" mean values don't change much in the upper 2km of the plume, which I don't see to be the case; both the backscatter Angstrom exponent (Figure 6) and (to a lesser degree) aerosol depolarization (Figure 7) change with altitude. Do you mean that at a given altitude these properties are quite invariant?

Pg. 6, lines 179-181: "This suggests strongly that the original particles near the source of combustion have been coated before they cross the land-ocean boundary and maintain their size over the first few days of transport over the ocean." What is the relationship between a change in aerosol size driven by changes in coating and changes in the lidar ratio, Angstrom exponent and depolarization? How sensitive are each of these parameters to changes in coating and size? Please be more quantitative.

Pg. 6, lines 181-182: "The lower portion of the plume containing larger BB aerosol particles is subject to mixing with other particles and is highly variable in nature." Why is the lower part of the plume more subject to mixing with "other particles" than the upper part of the plume? What is the source of these "other particles"?

pg. 7, lines 212-213: "The increase in depolarization (Fig. 7) at these lower levels and a decrease in the Lidar Ratio (Fig. 8) suggest mixing with continental and marine particles." Again, what is meant by "continental" particles needs to be specified.

Pg 7, lines 215-216: "The effective radius is 0.16±0.1 um with little variation throughout the vertical extent of the plume." Is this average +/- standard deviation calculated within given altitude ranges? i.e. what is defined as "the plume"? It would be very helpful in the figure to show what's considered "in the plume", for example by adding horizontal lines to the figures defining the bottom and top of the plume.

Pg 7, lines 221-222: “Here again, the effective radius of the submicron fraction of particles, 0.15 μm, is uniform with altitude, and comparable though biased slightly low.” This is confusing: First, is it 0.15 or 0.16 um? (a small difference, but confusing nonetheless). Second, “biased slightly low” compared to what? Or are you talking about the results from Sawamura et al.?

Pg 7, line 236: I don’t understand what is meant by the aerosol being “tenuous”