

Review of Friberg et al., 2023

The manuscript of Friberg et al. focuses on stratospheric impact of smoke from the 2019/2020 Australian wildfires. They define two events of smoke injection for their study and find a half-life time of the smoke of 10 days. They claim it to photochemical processing of organic aerosol. The manuscript should contain more references and a more convincing argumentation that photochemical processing played a significant role in the decrease of smoke AOD – in the current version of the manuscript it is not convincing. Below, the main concerns are listed in more detail:

Main concerns:

What lidar ratios at 532nm are used to evaluate CALIOP observations for volcanic sulfate and Australian smoke?

Please check the papers Ohneiser et al., ACP, 2020 and Ohneiser et al., ACP, 2022. These papers may serve as reference for all the satellite observations (CALIOP, OMPS, AOD).

You argue that the life-halftime is 10 days because the smoke particles dissolve. How could Ohneiser et al., ACP, 2022 observe the smoke then for 1-2 years after the emission? Please comment on that.

20°-80°S mean, this is from the tropics to the polar region. What about 30°-70°S? That can be better compared with the reference lidar observations above Punta Arenas at 53°S.

Referencing seems to be arbitrary, especially in the Introduction. A good overview: What is already available (regarding this record-breaking event) together with appropriate references would be helpful! Which gaps are left and filled by this paper?

Specific concerns:

9 lofted

12 It was so inhomogeneous, how could one determine half-life? Decay is also a function of horizontal meridional dispersion.

21 Source

22 define extratropics

34 References

41 eruptions without `

51-56 Aging does not just remove/decrease smoke mass. How is that linked to the findings in Ohneiser et al., 2022: 20 months measurements, slow decay or even Canada, Siberia 5-8 months residence time. What about dispersion? Please add references.

73 kilometers

80 brackets away around Martinson source

80 define SH

104 show instead of shows

170-171 AOD CALIOP: What lidar ratios are used? Background and Calbuco and Australian fires. Please compare all these also with ACP, 2020 and Ohneiser et al., ACP, 2022.

216 Figure 2 instead of Fig 2

226 Decreasing depolarization ratio: put it into context with the findings in Baars et al. 2019 (for example) who found decreasing depolarization ratios after stratospheric smoke injection

233-244 Same as earlier comments: What about sedimentation, what about dispersion, why can the smoke be observed for such a long time, when you write that half-life is 10 days?

239-244 typically, the findings tend to a decreased BC fraction with time as the coating with organics increases with time. This is in contradiction with your findings please comment on that.

273 you could add Ohneiser et al. 2023 in that context (Ohneiser, K., Ansmann, A., Witthuhn, J., Deneke, H., Chudnovsky, A., Walter, G., and Senf, F.: Self-lofting of wildfire smoke in the troposphere and stratosphere: simulations and space lidar observations, *Atmos. Chem. Phys.*, 23, 2901–2925, <https://doi.org/10.5194/acp-23-2901-2023>, 2023.)

282-283 Rieger et al., GRL, 2021 show the opposite. Most of the smoke went south to 70-80°S. Why should the efficient transport pathway be to the north? In your Fig. 4, also most of the smoke is located south of 60°S.

312 Aging works also the other way around: Condensation of gases onto the particles, therefore they can have a long lifetime

365-373 These three literature entries are not included in alphabetical order

Fig. 1: Too busy, no text in the figure readable, too many subfigures, no legend, no continent boundaries visible, no latitude and longitude range visible

Fig. 2: X axis text missing, too many figures, too small text, use (a), (b), (c)... in the figure to be able to refer to different parts of the figure. The figure organization is very confusing. Always show the same right below each other and not all the subfigures in different sizes. Please use less subfigures if not every figure is important for the paper.

Fig. 3: Same as Fig. 2, too small, too confusing, too much.

Fig. 5: What is the orange point? What about self-lofting impact?

Fig. 6: What was the used Calbuco lidar ratio and Australian fire lidar ratio? 30-70°S would be better.

Fig. 7: How are these results in agreement with the only reference dataset in Ohneiser et al., ACP, 2020 and Ohneiser et al., ACP, 2022? There could be saturation effects.

Fig. 10: What about using latitude subregions: 30-40°S, 40-50°S, 50-60°S, 60-70°S?