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Comment on acp-2021-1015

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Community comment on "Five-satellite-sensor study of the rapid decline of wildfire smoke in the stratosphere" by Bengt G. Martinsson et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-1015-CC1, 2022

I have several questions to the obtained results. First of all let me state that the paper is well written and all the CALIOP data are very carefully analyzed and discussed. However, at the end of the arcticle, I was still puzzled with the question: What is now the impact of multiple scattering on the different observations? Are the final CALIOP results corrected for multiple scattering or not? Are effective (multiple-scattering affected) AODs (and extinction coefficients) shown or true (single-scattering-related) AODs? The same for the OMPS-LP observations. Do these measurements suffer from multiple scattering (strong forward scattering) or not? I am not familiar with the applied passive remote sensing technique, but I know that AERONET photometers, for example, have problems to correctly measure stratospheric AODs (Ansmann et al., ACP, 2018) because of the large field of view (FOV) of the receiving optics and due to the fact that the smoke layers in the stratosphere are far away from the measuring system. The multiple scattering effect can be as large as 20-30% in the case of AERONET observations, and this is not corrected!

We know that CALIOP suffers from multiple scattering in the case of mineral dust. The knowledge is unclear in the case of dense smoke. Probably, the multiple scattering parameter (eta) can be lower than 0.8, although the receiver field of view (FOV) of the space lidar CALIOP is of the order of 0.1 mrad.

Multiple-scattering-influenced smoke lidar ratios are shown in Fig.2a. Values are between 45 to 59 sr, on average, 49.5 sr. In the literature, we can find respective Canadian fire lidar ratios (single scattering lidar ratios) of 55-60sr (Hu et al., ACP, 2019). Haarig et al. (ACP, 2018) found about 70 sr at 532 nm. Hu et al. could not make use of the full Raman lidar method, whereas the values obtained by Haarig et al. are fully based on the Raman-lidar technique. Typically, smoke lidar ratios are 65 sr and higher at 532 nm. So, there is a significant multiple scattering effect, when the found lidar ratios are around 50sr.

Is the CALIOP multiple scattering effect now considered in Figure 5? To my opinion: Not! Because of the excellent agreement with OMPS-LP observations, I started to think about a multiple scattering effect in the OMPS-LP data. How large is the receiver FOV in the case of the OMPS-LP instrument? As mentioned, I am not familiar with the OMPS-LP method, therefore I have these simple questions.

Finally, I have comment on the effective lidar ratio retrieval. Is it justified to assume a clean (Rayleigh) atmosphere below a dense smoke plume? I would assume that there must be smoke, and if that is well mixed, you have no chance to see that. One could do some retrievals with enhanced smoke values, as part of an uncertainty analysis.

Last point, the layer-mean lidar ratio is then the backscatter-weighted mean lidar ratio (Ansmann, Appl. Opt., 2006). That means, the largest backscatter coefficients in the layer widely determine the layer-mean or better column lidar ratio, and the largest backscatter values are most likely linked to pronounced multiple scattering.

Ansmann, Appl. Optics, 45, 3367-3371 (2006), https://doi.org/10.1364/AO.45.003367

I hope all this helps a bit to clarify some points in this well written article. I enjoyed reading!