Review: Vernier et al., egusphere-2023-1116, 2023

The manuscript mainly deals with the perturbation of the stratospheric aerosol layer after the volcanic eruption of the Raikoke volcano in June 2019. The authors assume that the perturbation was (almost) exclusively caused by the conversion of emitted SO2 into sulfate aerosol.

The main results are presented in Figures 7 and 8. Figure 8 shows that the main perturbation occurred between 45°N to 90°N.

At the same time (July to December 2019), strong Siberian fires contributed to the UTLS aerosol load over the Arctic (at least from 60°-90°N), as reported by Ohneiser et al. (2021) and Ohneiser et al. (2023) for the latitudes from 85° to 90°N and by Ansmann et al. (2023) for the latitudes from 60°-90°N. See also Figure 1 in the review comment. Figure 1 is taken from Ansmann et al. (2023).

Part of the SAOD in Figure 8 was probably caused by Siberian smoke. The authors did not consider this additional pollution aspect in their study. According to Figure 1 in this review, the smoke contributed about 75% to the UTLS aerosol (mostly below 12 km height) and the Raikoke aerosol around 25% in the autumn of 2019 (mostly above 12 km height).

The presence of smoke had obviously an impact of the measured decay times in Figure 7 of the manuscript. The decay of the stratospheric perturbation after the Raikoke eruption should be similar to the decay after the rather similar Sarychev volcanic eruption in 2009. For the neighbor volcano Sarychev, that erupted exactly 10 years before Raikoke, Haywood et al. (2010) determined a decay time of 90-150 days (3-5 months). Now the decay time is 12 months or even longer according to Figure 7. The major volcanic Pinatubo eruption caused decay times of about 12-15 months because the sulfate plumes reached heights of 25-30 km, and sedimentation and removal then needs longer as for sulfate layers with top heights around 20-22 km (Raikoke aerosol).

Is it not possible that the presence of smoke prolonged the occurrence of pollution in the UTLS height range? Ohneiser et al. (2021) reported smoke until May 2020 over the central Arctic.

The following question needs to be discussed: Why is the decay time now 12 months and more and thus much longer than the 3-5 months in the case of the Sarychev sulfate aerosol?

The following aspect needs to be included in the discussion: The strong Siberian fires in the summer of 2019 and the resulting record-breaking smoke pollution of the Arctic troposphere and lower stratosphere (at least north of 60°N) in the second half of 2019 needs to be mentioned and the potential consequences for the simulations need to be discussed. In Ohneiser et al. (2023), several references are given that deal with the strong smoke burden over Arctic latitudes in 2019.

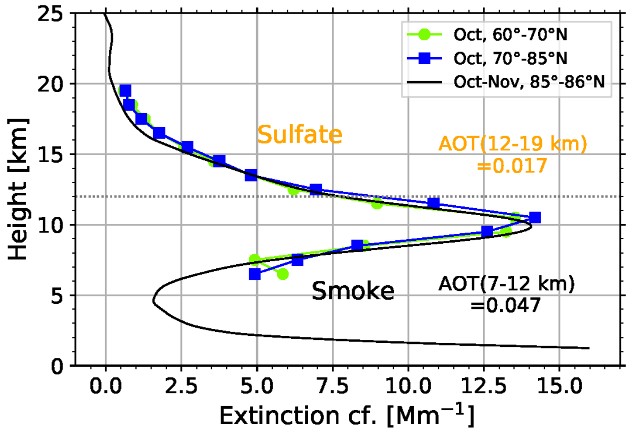

Figure 1: The Arctic UTLS aerosol layer in the fall of 2019 (Ansmann et al., 2023). The black solid line shows the 532 nm particle extinction coefficient (October-November mean profile) measured with ground-based Raman lidar during the MOSAiC expedition at 85°-86°N (Ohneiser et al., 2021). The blue and green profiles show October 2019 mean extinction profiles for the latitudinal bands from 60°-70°N (green) and 70°-85°N (blue) measured with the satellite-based ACE instrument (1020 atmospheric transmission channel) (Boone et al. 2022). The 1020 nm extinction profiles are multiplied by a factor 3. We hypothesize that Raikoke sulfate aerosol dominated at stratospheric heights above 12 km (dotted line) and wildfire smoke dominated in the upper troposphere up to the extinction maximum. AOTs for 532 nm measured at 85-86°N are given as numbers.

Ohneiser, K., et al., The unexpected smoke layer in the High Arctic winter stratosphere during MOSAiC 2019–2020, Atmos. Chem. Phys., 21, 15783–15808. doi: 10.5194/acp-21-15783-2021, 2021.

Ohneiser, K., et al., Self-lofting of wildfire smoke in the troposphere and stratosphere: simulations and space lidar observations, Atmos. Chem. Phys., 23, 2901–2925, doi: 10.5194/acp-23-2901-2023, 2023

Boone, C. D., et al., Stratospheric Aerosol Composition Observed by the Atmospheric Chemistry Experiment Following the 2019 Raikoke Eruption, JGR-Atmospheres, 127, doi: 10.1029/2022JD036600, 2022.

Ansmann, A., et al., Comment on ``Stratospheric Aerosol Composition Observed by the Atmospheric Chemistry Experiment Following the 2019 Raikoke Eruption'' by Boone et al., JGR-Atmospheres, 128, 2023, and will be published in August or September 2023.