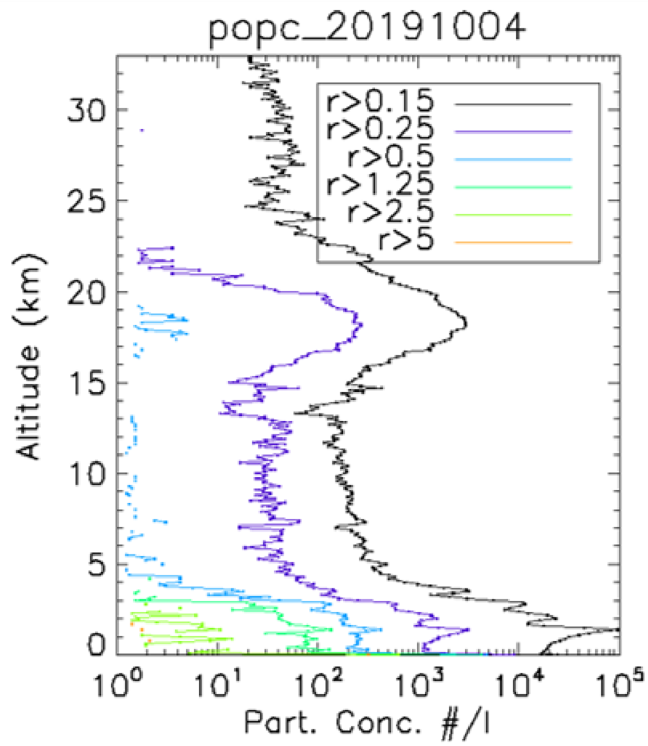
Response to Dr. Ansmann and Dr. Boone.

First, we would like to thank them for their interest in our paper and finding time to read and comment on it. This is very much appreciated. Given the fact that the comment from Dr. Boone is a response to Dr. Ansmann, we will provide an answer to both comments in the same document.

Dr. Ansmann raised an interesting point regarding the decay time of the Raikoke plume compared to the Sarychev eruption. He found that the decay time of Raikoke was significantly longer (12 months) than the one observed after the Sarychev eruption (3-5 months) as derived by Haywood et al. (2010). However, Dr. Boone provides compelling evidence in his reply that the extinction profiles at 1.02 µm from ACE Imager behave in a similar way for both eruptions so that Sarychev decay is not much faster than Raikoke. As a result, it's not required to invoke additional aerosol sources to explain the decay time of Raikoke.

However, Ohneiser et al. (2021) show Raman lidar profiles (Fig. 11/12) indicating that the optical properties of the aerosol layers observed during the MOSAiC project were consistent with smoke layers. Indeed, the lidar ratio at 532 nm is expected to be close to 50sr, a value usually assumed for the sulfate aerosol background conditions to convert backscatter coefficient into extinction. Mattis et al. (2010) found a value similar (40 sr) using ground-based lidar over Germany after several volcanic eruptions. However, Ohneiser found a lidar ratio at 532 nm near 80 sr and thus apparently significantly higher than expected. This would be an indication of the presence of smoke. While Ohneiser al. (2021) still claims that the Raikoke plume is likely located above 12-13 km at the top of the smoke layer, they do not report optical properties to confirm that leaving this very important aspect unclear. In addition, one would expect some sort of transition between two layers displaying different optical properties especially several months following events due to microphysical processes (coagulation, growth, sedimentation). Instead, profiles provided in Ohneiser et al. (2023) and in Drs. Boon/Ansmann's comments show a good continuity along the vertical profile.

In addition, our team conducted several balloon flights from Hampton, VA in October and November 2019 after the Raikoke eruption (paper not yet published). We included profiles of aerosol concentrations for several size bins. While Hampton (37.09, -76.37) is far from the locations of the MOSAIC project located in the Artic region, we could expect that that residual smoke from the summertime in Siberia could have been transported across the Northern Hemisphere after several months. The concentration profiles shown below indicate an aerosol layer between 15-24 km (above the local tropopause ~12km). We note that this layer does not display any significant changes in the vertical structure of the size channels where most of the aerosols size range within 0.15-0.25 µm. The thickness of the layer and its position relative to the tropopause is consistent with the one reported in the comments by Dr. Ansmann and Dr. Boone as well as in Ohneiser et al. (2021) but with a peak at higher altitude given the isentropic transport expected from polar region to mid-latitudes.



Particle Concentration profiles for aerosol radius greater than 0.15, 0.25, 0.5, 1.25, 2.5 and 5 µm obtained in Hampton VA on 4 October 2019 using the Particle plus Optical Particle Counter (see description in Dumelie et al., 2023, Li et al., 2023).

In summary, we added in the manuscript a comment mentioning Ohneiser et al. (2021) and the potential role of smoke on aerosols near the tropopause after the Raikoke eruption but believe that a major and prolonged influence of smoke is unlikely and that most of the SAOD is likely from the 2019 Raikoke. Nevertheless, we cannot rule out an influence from wildfire Siberia smoke.

References

Dumelié, N., and Coauthors, 2023: Toward Rapid balloon Experiments for sudden Aerosol injection in the Stratosphere (REAS) by volcanic eruptions and wildfires. *Bull. Amer. Meteor. Soc.*, https://doi.org/10.1175/BAMS-D-22-0086.1, in press.

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