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Detection of an enhanced stratospheric aerosol layer above Europe one year after the eruption of the volcano Raikoke

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Extreme volcanic eruptions inject significant amounts of sulfur-containing species into the lower stratosphere and sustain the stratospheric aerosol layer which tends to cool the atmosphere and surface temperatures.

During the BLUESKY campaign in May/June 2020, the aerosol composition and its precursor gas SO₂ were measured with a time-of-flight aerosol mass spectrometer onboard the research aircraft HALO and with an atmospheric chemical ionization mass spectrometer onboard the DLR Falcon. While SO₂ was slightly above background levels in the lower stratosphere above Europe, the aerosol mass spectrometer detected an extended aerosol layer. This sulfate aerosol layer was observed on most of the HALO flights and the sulfate mixing ratio increased significantly between 10 and 14 km altitude. Back trajectory calculations show no recent transport of polluted boundary layer air or ground-based emissions into the lower stratosphere. Therefore, we suggest that the stratospheric sulfate aerosol layer might be attributed to the aged stratospheric plume of the volcano Raikoke in Japan. In June 2019, Raikoke injected huge amounts of SO₂ into the lower stratosphere, which were converted to sulfate and contributed to the stratospheric aerosol layer. This decaying volcanic aerosol layer was observed with the aerosol mass spectrometer over Europe a year after the eruption. The long-term volcanic remnants enhance the total stratospheric aerosol surface area, facilitate heterogeneous reactions on these particles and provide additional cloud condensation nuclei in the UTLS. They further offset some of the reduced sulfur burden from aviation that was observed during the COVID-19 lockdown in 2020.

The sensitive and highly time resolved airborne measurements of composition and size of stratospheric aerosol from an explosive volcanic eruption help to better constrain sulfur chemistry in the lower stratosphere, validate satellite observations near their detection threshold and can be used to evaluate dispersion and chemistry-climate models on long-term effects of volcanic aerosol.