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Measurements of particulate sulfate and organics of volcanic aerosol in the UT/LS three months after the 2008 eruptions of Mt. Okmok and Mt. Kasatochi

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After a relatively long period of volcanic quiescence, the explosive eruptions of Mt. Okmok on 12 July and Mt. Kasatochi on 7 August, 2008, at 52-53°N injected about 1.6 Tg SO2 into the lower stratosphere. SO2 in the stratosphere is converted to sulfuric acid, which efficiently forms stratospheric aerosol. Stratospheric volcanic aerosol is known to influence ozone abundance and the radiative budget and offers a reaction surface to heterogeneous chemistry. Especially considering the latter, it is of high interest to obtain information on the chemical composition and size distribution of the volcanic aerosol in the UT/LS. Approximately three months after the eruptions of Mts. Okmok and Kasatochi, a volcanic aerosol layer over Northern and Western Europe has been detected by online aerosol mass spectrometry in the lower stratosphere (LS). During three out of six scientific flights carried out with the German research aircraft Falcon as part of the CONCERT (CONtrail and Cirrus ExpeRimenT) campaign, unusually high concentrations of submicron sulfate and organic aerosol were measured with an Aerodyne compact time-of-flight aerosol mass spectrometer (C-ToF-AMS) that detects particles in a size diameter range between 40 nm and 800 nm. While background particulate sulfate concentrations above the 2-PVU boundary (PVU = potential vorticity units) did not exceed 0.2 μg m-3 (STP) the average concentration within the layers was enhanced by a factor of 4 including a maximum of 2.0 μg m-3 (STP). Based on accompanying SO2 gas-phase measurements, an 80 % conversion of sulfur dioxide into sulfuric acid droplets during the 85 days after the Kasatochi eruption was estimated. In total, the volcanic aerosol was found to be composed of 71 % sulfate, 21 % highly oxygenated low-volatile organic matter and 8 % ammonium. The organic carbon was enhanced by a factor of 1.4 compared to background LS aerosol. The mean diameter of the mass size distribution was 360 nm vacuum aerodynamic diameter (dva), corresponding to approximately 200 nm mobility diameter.
More specifically, the plumes were detected over the North Sea (3 – 8° E, 51 – 53° N) and the North Atlantic (4° E - 14°W, 49 – 52° N, and 4° E – 12° W, 48 – 51° N) between 8 and 12 km altitude always above the tropopause. According to meteorological data, such as potential vorticity and potential temperature, the layer descended from higher altitudes within a tropopause fold and could thus be detected by the research aircraft. Other sources than volcanic eruptions such as air traffic, OCS conversion, and vertical convective transport could be ruled out. Additionally, data from German LIDAR stations at Kühlungsborn and Leipzig underline the conclusion that volcanic aerosol was observed during the CONCERT campaign.
To our knowledge these are the first measurements of stratospheric volcanic aerosol by an online aerosol mass spectrometer revealing that not only particulate sulfate but also carbonaceous matter was present. Even though this has been found by offline methods before, the origin of the organic compounds is not fully understood.