The impact of the 1783–1784 AD Laki eruption on global aerosol formation processes and cloud condensation nuclei

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The 1783–1784 AD Laki flood lava eruption commenced on 8 June 1783 and released 122 Tg of sulphur dioxide gas over the course of 8 months into the upper troposphere and lower stratosphere above Iceland. Previous studies have examined the impact of the Laki eruption on sulphate aerosol and climate using general circulation models. Here, we study the impact on aerosol microphysical processes, including the nucleation of new particles and their growth to cloud condensation nuclei (CCN) using a comprehensive Global Model of Aerosol Processes (GLOMAP). Total particle concentrations in the free troposphere increase by a factor ~16 over large parts of the Northern Hemisphere in the 3 months following the onset of the eruption. Particle concentrations in the boundary layer increase by a factor 2 to 5 in regions as far away as North America, the Middle East and Asia due to long-range transport of nucleated particles. CCN concentrations (at 0.22% supersaturation) increase by a factor 65 in the upper troposphere with maximum changes in 3-month zonal mean concentrations of ~1400 cm^{-3} at high northern latitudes. 3-month zonal mean CCN concentrations in the boundary layer at the latitude of the eruption increase by up to a factor 26, and averaged over the Northern Hemisphere, the eruption caused a factor 4 increase in CCN concentrations at low-level cloud altitude. The simulations show that the Laki eruption would have completely dominated as a source of CCN in the pre-industrial atmosphere. The model also suggests an impact of the eruption in the Southern Hemisphere, where CCN concentrations are increased by up to a factor 1.4 at 20° S. Our model simulations suggest that the impact of an equivalent wintertime eruption on upper tropospheric CCN concentrations is only about one-third of that of a summertime eruption. The simulations show that the microphysical processes leading to the growth of particles to CCN sizes are fundamentally different after an eruption when compared to the unperturbed atmosphere, underlining the importance of using a fully coupled microphysics model when studying long-lasting, high-latitude eruptions.

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