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Aerosol and gas emissions from Holuhraun eruption 2014-2015: size-resolved chemistry at source and in exposed communities

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The Holuhraun eruption 2014-2015 (6-month duration) was the first scientific opportunity to directly observe the emission and dispersion of a volcanic plume from a large Icelandic fissure eruption, an eruption type that can greatly impact the environment due to their prolonged high flux emissions of reactive gases and aerosol.

We present a comprehensive dataset to characterise the chemistry of aerosol and gas in the Holuhraun plume. The plume was sampled at the eruptive vent, and in two populated areas in Iceland located at different distances downwind of the volcano: Reykjahlíð town (100km), and Reykjavík capital area (250km). The dataset comprises a detailed analysis of major and trace species in the volcanic plume, including size-resolved chemistry of the aerosol phase. We also present a time series of volcanic air pollutants (SO_2, PM2.5 and sulphate aerosol) in the populated areas.

The results show that the plume was very diverse in its chemical composition, and 75-80% of the volcanic aerosol mass was in the PM2.5 size fraction. The plume had detectable concentrations of a large number of major and trace species in the aerosol phase, even when sampled in the populated area far downwind. The plume caused repeated air pollution events in the populated areas, exceeding the EU hourly exposure standards (350 μg/m3) for SO_2 on 88 occasions in Reykjahlíð town, and 34 occasions in Reykjavík capital area. The annual limit for daily exceedances (3 days) was also surpassed in both areas (10 and 7 days, respectively). Average 24-hour concentration of volcanogenic sulphate exceeded 5 μg/m3 on 30 days in Reykjavík capital area.

We detected two 'types' of plume that reached the downwind populated areas at ground level. The first type, a 'young plume' had high concentrations of both SO_2 and sulphate, with a high gas/aerosol ratio. The second type, an 'aged plume' had low SO_2 and high sulphate, where sulphur had undergone complete or near-complete gas-to-aerosol conversion. Both types of plume were rich in both sulphate (on average $\sim$90% of the particle mass) and various trace species, including heavy metals. The fine size of the volcanic aerosol (predominantly PM1.0 and PM2.5) and the high environmental lability of its chemical components have implications for adverse health and environmental impacts. We make a recommendation that both 'types' of plume are forecasted and monitored during future eruptions.