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Impact of the Holuhraun flood lava eruption at Bardarbunga volcano (Iceland, 2014-15) on European aerosol properties.

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The long-lasting Holuhraun flood lava eruption at Bardarbunga volcano (Iceland) emitted massive amounts of sulfur dioxide (SO_2) into the lower troposphere in 2014-15, representing the fifth largest source of eruptive volcanic SO_2 emission over the 1978-2014 period (Carn et al., 2016). This eruption resulted in multiple short-lived air pollution episodes on a continental scale, affecting many European countries, from Scandinavia down to France in latitude, and from the UK to Poland in longitude. Once in the atmosphere, SO_2 is oxidized via gas- and aqueous-phase reactions to form sulphur-rich aerosols which can impact both human health and climate.

Various studies have investigated the long-range atmospheric pollution induced by volcanic SO_2 as well as the large-scale modifications of cloud microphysics. However, an extensive set of observations of the changes in aerosol budget and properties due to the Holuhraun eruption is lacking. We aim here at filling this gap.

While the volcanic origin of SO_2 can be easily proven using satellite imagery which allows to track the volcanic plume from the source, the demonstration of the volcanic origin of sulfur-rich aerosols is not straightforward. To do so, we jointly analyse a set of SO_2 observations together with data from ground-based networks for remote and in-situ aerosol observations. SO_2 is tracked using satellite imagery from multiple spaceborne sensors spanning from the UV to IR spectral ranges (OMI, OMPS, IASI) as well as ground-level measurements from air quality monitoring networks. On the aerosol side, we explore a vast set of remote sensing (sunphotometry, LIDAR) and in-situ ground-level observations. The analysis of sunphotometric measurements, at about twenty stations distributed in northern-western Europe as part of the AERONET (AErosol RObotic NETwork) network, provides a detailed characterization of the optical properties (optical depth, Angstrom exponent) and the size distribution of aerosols. EMEP in-situ surface data at various stations provide complementary information on sulfate aerosol mass concentrations at ground-level. Finally, LIDAR measurements are also exploited at specific locations to inform on the vertical distribution of these aerosols.

This study allows us to describe and quantify the long-range impact of the Holuhraun eruption on the European budget of aerosols and to characterize their optical and microphysical properties. Contrary to the stratosphere, the monitoring of tropospheric sulfur-rich aerosols is difficult. The extensive set of observations analysed here should also enable to validate forthcoming modelling studies of the lifecycle of volcanic sulfur in tropospheric plumes using state-of-the-art chemistry-tranport models.