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High Proportions of Sub-micron Particulate Matter in Icelandic Dust Storms in 2015

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Iceland is extremely active dust region and desert areas of over 44,000 km2 acknowledge Iceland as the largest Arctic and European desert. Frequent dust events, up to 135 dust days annually, transport dust particles far distances towards the Arctic and Europe. Satellite MODIS pictures have revealed dust plumes exceeding 1,000 km. The annual dust deposition was calculated as 40.1 million tons yr-1.

Two dust storms were measured in transverse horizontal profile about 90 km far from different dust sources in southwestern Iceland in the summer of 2015. Aerosol monitor DustTrak DRX 8533EP was used to measure PM mass concentrations corresponding to PM1, PM2.5, PM4, PM10 and the total PM15 at several places within the dust plume. Images from camera network operated by the Icelandic Road and Coastal Administration were used to estimate the visibility and spatial extent of measured dust events. A numerical simulation of surface winds was carried out with the numerical model HIRLAM with horizontal resolution of 5 km and used to calculate the total dust flux from the sources.

The in situ measurements inside the dust plumes showed that aeolian dust can be very fine. The study highlights that suspended volcanic dust in Iceland causes air pollution with extremely high PM1 concentrations comparable to the polluted urban stations in Europe or Asia rather than reported dust event observations from around the world. The PM1/PM2.5 ratios are generally low during dust storms outside of Iceland, much lower than > 0.9 and PM1/PM10 ratios of 0.34-0.63 found in our study. It shows that Icelandic volcanic dust consists of higher proportion of submicron particles compared to crustal dust.

The submicron particles are predicted to travel long distances. Moreover, such submicron particles pose considerable health risk because of high potential for entering the lungs. Icelandic volcanic glass has often fine pipe-vesicular structures known from asbestos and high content of heavy metals. Previous in situ measurements at the dust source in 2013 revealed extremely high number concentrations of submicron particles, specifically in the size range 0.3-0.337 μm. The PM2.5/PM10 ratios of mass concentrations seem to be lower at the dust sources that in some distance from the sources as measured in 2015.

Common dust storms in Iceland are of several hundred thousand tons of magnitude from relatively well defined main dust sources. Numerical simulations were used calculate the total dust flux from the sources as 180,000 - 280,000 tons in this study. The mean PM1 (PM10) concentrations inside of the dust plumes varied from 97 to 241 μg m-3 (PM10 = 158 to 583 μg m-3). The extent of moderate dust events was calculated as 2.450 km2 to 4.220 km2 of the land area suggesting the regional scale of the events. Dust plumes reported here passed the most densely inhabited areas of Iceland, health risk warnings for the general public were, however, not issued. The data provided stresses the need for such warning system and is an important step towards its development.