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Big volcanic ash grains, even from small plumes, travel long distances: implications for satellite remote sensing.

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Estimates of the size distribution of particles in distal volcanic ash clouds derived from satellite remote sensing data (most particles <10 microns) differ significantly from the size of particles observed on the ground by tephrochronologists (mainly 20-40 microns, can be <100 microns). The brightness temperature difference (BTD) method for detecting volcanic ash has low sensitivity to particles coarser than 32 microns diameter and it is generally assumed that they make a negligible contribution to the mass of ash in the cloud, having been deposited close to the volcano. Here we question this assumption and investigate the how the presence of coarse ash affects the uncertainty in satellite-derived estimates of mass loading.

Mathematical models based on Stokes' settling predict the range of a dense, spherical, 30 micron grain settling from 9 km in 15 meters per second wind is 2000 km. This range is more than doubled when irregularly-shaped, vesicular particles are taken into account. Grainsize distributions from the Askja 1875, Eyjafjallajökull 2010 and Grímsvötn 2011 eruptions at distances of 1200 km, 650 km and 950 km have modes of 52 microns, 45 microns and 25 microns. Air quality data from Grímsvötn 2011 indicate that more than 75% of airborne ash near the ground in North Scotland on 24 May was >10 microns diameter, but it is difficult to determine the proportion of coarser particles at higher altitudes.

The effect of coarse particles on remote sensing data was investigated with simulated satellite images created using model-derived grainsize distributions, numerical weather prediction data and a radiative transfer model. Changes in the number of pixels identified as volcanic ash and in the retrieved mass loading were calculated as an increasing proportion of optically-inactive coarse particles was added to the simulated ash cloud. Results show that there is a significant reduction in the ash mass loading retrieved from the simulated satellite data when the proportion of coarse particles increases; this illustrates the need to consider the presence of large particles when using satellite retrievals in the operational context of a Volcanic Ash Advisory Centre.