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Reference dataset of volcanic ash physicochemical and optical properties for atmospheric measurement retrievals and transport modelling

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Explosive volcanic eruptions emit up to 50 wt.% (total erupted mass) of fine ash particles (<63 microns), which individually can have theoretical atmospheric lifetimes that span hours to days. Depending on the injection height, fine ash may be subsequently transported and dispersed by the atmosphere over 100s – 1000s km and can pose a major threat for aviation operations. Recent volcanic eruptions, such as the 2010 Icelandic Eyjafjallajökull event, illustrated how volcanic ash can severely impact commercial air traffic. In order to manage the threat, it is important to have accurate forecast information on the spatial extent and absolute quantity of airborne volcanic ash. Such forecasts are constrained by empirically-derived estimates of the volcanic source term and the nature of the constituent volcanic ash properties. Consequently, it is important to include a quantitative assessment of measurement uncertainties of ash properties to provide realistic ash forecast uncertainty. Currently, information on volcanic ash physicochemical and optical properties is derived from a small number of somewhat dated publications.

In this study, we provide a reference dataset for physical (size distribution and shape), chemical (bulk vs. surface chemistry) and optical properties (complex refractive index in the UV-vis-NIR range) of a representative selection of volcanic ash samples from 10 different volcanic eruptions covering the full variability in silica content (40-75 wt.% SiO_2). Through the combination of empirical analytical methods (e.g., image analysis, Energy Dispersive Spectroscopy, X-ray Photoelectron Spectroscopy, Transmission Electron Microscopy and UV/Vis/NIR/FTIR Spectroscopy) and theoretical models (e.g., Bruggeman effective medium approach), it was possible to fully capture the natural variability of ash physicochemical and optical characteristics. The dataset will be applied in atmospheric measurement retrievals and atmospheric transport modelling to determine the sensitivity to uncertainty in ash particle characteristics.