The fate of volcanic ash aggregates: premature or delayed sedimentation?

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Most volcanic ash produced during explosive volcanic eruptions sediments as aggregates of various types that typically have a greater fall velocity than the particles of which they are composed. As a result, aggregation processes are commonly known to affect the sedimentation of fine ash by considerably reducing its residence time in the atmosphere. Nonetheless, speculations also exist in the literature that aggregation does not always result in a premature sedimentation of their constitute particles but that it can also result in a delayed sedimentation (i.e. the so-called rafting effect). However, previous studies have considered rafting as a highly improbable phenomenon due to a biased representation of aggregate shapes.

Here we provide the first theoretical evidence that rafting may not only occur, but it is probably more common than previously thought, helping to elucidate often unexplained field observations. Starting from field evidence of rafted aggregates at Sakurajima Volcano (Japan), we clarify the conditions for which aggregation of volcanic ash results either in a premature or a delayed sedimentation.

Moreover, using the Lagrangian dispersion model NAME, we show the practical consequences of rafting on the final sedimentation distance of aggregates with different morphological features. As an application we chose the case study of the 2010 eruption of Eyjafjallajökull volcano (Iceland), for which rafting can increase the travel distances of ash <500 μm up 3.7 times with respect to sedimentation of individual particles.

These findings have fundamental implications both for real-time forecasting and long-term hazard assessment of volcanic ash dispersal and sedimentation and for weather modelling. The constraints on rafting presented and discussed in this work will help the scientific community to clarify the often unexpected role of aggregation in creating a delayed sedimentation of coarse ash.