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## Ensemble-based volcanic ash forecasts using satellite retrievals for quantitative verification

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Volcanic ash poses a significant hazard for aviation. If an ash cloud forms as result of an eruption, it forces a series of flight planning decisions that consider important safety and economic factors. These decisions are made using a combination of satellite retrievals and volcanic ash forecasts issued by Volcanic Ash Advisory Centres. However, forecasts of ash hazard remain deterministic, and lack quantification of the uncertainty that arises from the estimation of eruption source parameters, meteorology and uncertainties within the dispersion model used to perform the simulations. Quantification of these uncertainties is fundamental and could be achieved by using ensemble simulations. Here, we explore how ensemble-based forecasts — performed using the Met Office dispersion model NAME — together with sequential satellite retrievals of ash column loading, may improve forecast accuracy and uncertainty characterization.

We have developed a new methodology to evaluate each member of the ensemble based on its agreement with the satellite retrievals available at the time. An initial ensemble is passed through a filter of verification metrics and compared with the first available set of satellite observations. Members far from the observations are rejected. The members within a limit of acceptability are used to resample the parameters used in the initial ensemble, and design a new ensemble to compare with the next available set of satellite observations. The filtering process and parameter resampling are applied whenever new satellite observations are available, to create new ensembles propagating forward in time, until all available observations are covered.

Although the method requires the run of many ensemble batches, and it is not yet suited for operational use, it shows how combining ensemble simulations and sequential satellite retrievals can be used to quantify confidence in ash forecasts. We demonstrate the method by applying it to the recent Raikoke (Kurii Islands, Russia) eruption, which occurred on the 22<sup>nd</sup> July 2019. Each ensemble consists of 1000 members and it is evaluated against 6-hourly HIMAWARI satellite ash retrievals.