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Reply on RC2

Antonio Capponi et al.

Author comment on "Refining an ensemble of volcanic ash forecasts using satellite retrievals: Raikoke 2019" by Antonio Capponi et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-858-AC2, 2022

We thank the reviewer for the detailed comments on the manuscript. Please find below our response (in bold and italic) to all the remarks requiring revisions or elucidations, and how and where the manuscript has been modified according to the comments.

Anonymous Referee #2

Referee comment on "Refining an ensemble of volcanic ash forecasts using satellite retrievals: Raikoke 2019" by Antonio Capponi et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-858-RC2, 2022

The paper "Refining an ensemble of volcanic ash forecasts using satellite retrievals: Raikoke 2019" by Antonio Capponi et al. presents a methodology to improve numerical forecasts of volcanic ash by assimilating satellite retrievals of the investigated ash cloud. The authors apply this methodology to the volcanic cloud produced by the recent Raikoke eruption, and show interesting results with implications for volcanic hazard assessment. I found the paper timely, interesting and clear. The methodology is well described, and the application to the Raikoke eruption is clear. The discussions are in line with the results presented and the conclusions are very interesting. For these reasons, I suggest publication after minor revisions. Here below my comments and questions.

L68 The recent paper "Data assimilation of volcanic aerosol observations using FALL3D+PDAF" by Mingari et al., 2022 could be cited as well.

We added the suggested reference in L70

L140 Just for curiosity, with this retrieval algorithm can you also provide estimates of plume height? For the future, I think it would be very interesting to include in the data assimilation methodology the height of the volcanic cloud. Would it be feasible?

***Yes, the algorithm can provide plume height estimates within the produced files for use within InTEM. In the operational form of InTEM at the Met Office this information is not used. The main reason for this is that it would likely not be useful. In general, the accuracy of the NAME modelled height of the ash should be better than the satellite retrieved height, when considering a location where both the satellite and NAME model has ash. This is because there is usually sufficient vertical shear in the atmospheric winds that for NAME to get the ash at the correct horizontal location it needs to be at close to the correct vertical height. As a result, it would likely be a waste of effort to use this data in a sensible way*.**

L162 "All simulations" indicate the simulations forming all the ensembles, not only the first one, right? Please add information.

Yes, it is all simulations forming each ensemble. We specified this at the beginning of the sentence (L167)

L212 Could you provide information on the computational time necessary to run 1000 simulations? Do you run them in parallel or in serial mode?

We added the information on computational times necessary to run both a single simulation (1 member of an ensemble) and an entire ensemble in L154-157

L268 Please describe all the parameters of eq. 1. not only H, but also g,h and r.

g hr^{-1} specifies the measurement unit for the Mass eruption rate. We moved the unit in L281 to avoid confusion.

L310 Is MOGREPS-G the same as MOGREPS?

It's called MOGREPS-G to differentiate it from MOGREPS-UK which is a high-resolution ensemble. MOGREPS-UK is a more recent creation which is why some early literature simply refers to MOGREPS. We changed all to MOGREPS-G throughout the text.

L397 Why did you exclude ENS03?

We wanted to show the difference between two subsequent Ensembles (01 and 02) and between two ensembles after 12 hours (Ens 02 and 04). We now modified the figure by removing the correlation matrix comparison (shown now

in the new Figure 5), and adding ENS03, showing the evolution of distributions for EN01, 02, 03 and 04.

L423-428 I think that more details should be given on the resampling strategy for the posterior pdfs. The correlation matrix (also in Fig.4) and the Cholesky decomposition should be better described.

We have added the details of our resampling strategy in the new LL440-455. In addition, we have added a new Figure, Fig. 5, showing an example of distribution fitting for one of the ESPs (Fig. 5a) and moved the comparison between correlation matrices originally in Fig. 4b to Fig. 5b.

L434 Is the trend of the distributions confirmed also for the ensembles not shown in Fig. 5? I think that this figure should be described giving more details. In particular, the fact that most of the ESPs are skewed towards the lower end of the initial range is interesting and I am curious to understand if you could validate these findings on the ESPs with independent observations of the same quantities. Could you compare the height of the column that emerges from this methodology with independent observations? Particle density seems to be conserved. Could you provide an explanation for that?

We have added in the Appendix the evolution of the distributions for ENS07 to ENS11 (Fig. B1). The trends in these later iterations are similar to ENS02-06. However, a noticeable variation occurs for the plume height in ENS10 and 11, with H increasing noticeably. This variation agrees with variations in plume heights observed by Muesel et al (2020) and Bruckert et al (2021). Here, the authors reported an increase of more than 6 km or more of the maximum plume top height in the days following the eruption starting from around 12 km (+/- 1.5 km) after the onset of the eruption and reaching ~20 km of height in the fourth day after the eruption. This increase was related to aerosol–radiation interaction leading to warming of the ash and a subsequent increase of plume height. This top height agrees with the outcome of the ENS10 and 11 and increase in H that can be also observed for ENS08 and 09 (Fig. B1). Generally, as also stated in the conclusions, a useful follow up would be to use different and independent datasets to validate these results.

Regarding the density: despite it seems to be conserved compared to other parameters, it slowly seems to peak as well. The fact that it is not showing clear variations compared to other ESPs, may be related to the initial range of density: it is based on literature values and probably it was a good approximation for Raikoke from the start.

L461 The figure is well done, but it is really difficult to see the contour lines. Is there a way to improve the readability of the panels?

We modified the figure (now Figure 7), removing the 0-30% contour to make the panels clearer (but we kept the original as Appendix C1), and leaving the comparison only for the 30-100% contours among ENS01, 03 and Control Run. We also added coordinates labels.

L532 It is not immediately evident that panels (a) and (b) indicate the concentration risk of the prior ensemble and ens08, respectively. Maybe subtitles could be added in order to make the comparison between the prior ensemble and ens08 more easy and immediate. The same for the ash dose risk of panels (c) and (d)

We modified the figure (now Figure 9) and added the labels to all panels.