

## ***Interactive comment on “Satellite data assimilation to improve forecasts of volcanic ash concentrations” by Guangliang Fu et al.***

### **Anonymous Referee #2**

Received and published: 12 August 2016

#### General comments:

This paper comprises nice work of the investigation of an ensemble square root filter to assimilate 2D volcanic ash mass loadings retrieved from SEVIRI satellite measurements. In detail a satellite observational operator is developed to enable the comparison between the 3D modelled ash concentrations and the 2D volcanic ash mass loading observations. Thereby, the authors focus on the measurement geometry and they define uncertainties and discuss errors in a proper and detailed way. By validation of the assimilation analysis with independent aircraft in-situ measurements the assimilation performance is evaluated and the improvements are assessed to be of benefit to aviation advice.

This study is of special interest to atmospheric science, since it applies a set of re-

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trieved satellite remote sensing data in a new manner to a 3D assimilation system. Additionally, improvements of volcanic ash dispersion forecasts are meaningful to scientist, because better understanding of the system of the atmosphere can be achieved. To the reviewer's knowledge, the usage of an ensemble square root filter for volcanic ash assimilation is a new approach and the analysis concept of the paper is well structured and mainly clearly outlined.

But still, some analysis steps, especially the derivation of the SOO and the discussion of aviation advice need some additional revision (see specific comments below). Consequently, the conclusions should be rewritten, so that the conclusions are consistent and substantial. The choice of the figures should be reconsidered. Misspellings and minor grammatical issues do still appear in this paper and should be corrected implicitly.

Specific comments:

P 1, L 15: I query that Fu et al., 2015 is the right paper to cite at this point.

P 2, L 5: Aggregation is discussed, but isn't sedimentation the more important process. Is it included in the model calculations?

P 2, L 17-19: For remote volcanoes it is hard to perform measurement campaigns, especially as consequence of sudden eruptions. Treat such sentences carefully.

P 2, L 19-21: Don't forget about other ground based remote sensing techniques besides LIDAR.

Chap. 2: Please point out which retrieval techniques are included in the VAST-data set and which additional retrieval or processing was done by the authors of the paper. Unfortunately, data cannot be accessed, due to not working registration – but this is not the author's fault.

P 4, L 5-11: The discussion of the Marengo et al., 2011 paper seems a bit out of context here. Please specify the meaning of that publication to this paper. Maybe this

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discussion could take place in Chap. 3.1.

P 4, L 10: Treat the expression of the “entire volcanic ash plume” carefully. Close to the emission source the layering of volcanic ash did not necessarily take place.

Chap. 3.1: To me it remains unclear, how the outcome of this SOO, as pre-processing to the assimilation, looks like. Is the extracted data only the data of 0.5 km layer thickness? Or does the extracted ash layer have the thickness of T\_high? Or is the iterative layer thickness only used for the derivation of uncertainties?

P 4, L 27: “100 % certainty” is a dare statement. You are ignoring the retrieval errors of ash plume top height of the SEVIRI data and it might be possible to have ash layers smaller than 0.5 km thickness.

Chap. 3.2: The discussion of the ash effective particle radius seems a bit out of context. Is this even an observational parameter you are considering in your assimilation study? If not, then Fig. 1b might be of no interest to this study.

Chap. 4.2: I really like the detailed discussion of the measurement error. Nice chapter!

P 7, L 27-28: “... the overestimation has almost vanished.” At this point it is not inferable that an overestimation appeared. Be careful with such assessments. Observations have large uncertainties, too. Independent data to compare would be necessary to do such judgements.

Chap. 5.2: Throughout this chapter it is important to precisely declare the regions where aviation advice can really be given. Talking about “entire Europe” while the study only takes place in the North-Western part of Europe is not acceptable. Aviation advice can only be given in areas where the assimilation took place and certainly only for the region which was additionally validated by independent observations. The note corresponding to near volcano regions and more certain advices at the end of this should be discussed already earlier. Moreover, it is discussed that the assimilation result is closer to the independent flight observations in North-West Germany, but

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actually in this region the aviation advice for the forecast without assimilation would be similar, because the ash concentration in this area is far below 4 mg/m<sup>3</sup> (see also Fig. 6d).

Chap. 6: Most parts of the conclusions chapter should be rewritten according to the changes discussed above.

P 10, L 11: “also measurements of the ash cloud thickness” -> Aren't you deriving the cloud thickness with the SOO?

Comments on figures:

Fig. 1: see comment to Chap. 3.2. Is Fig. 1b of interest to this study? If yes the choice of the colour table range should be revised.

Fig. 4: What height is the cloud top layer at 1:00 UTC, 16 May 2010? And is the cloud top layer height changing due to the EnSR? Model and observations heights might differ.

Fig. 6: To me there is no important information included in Fig. 6a. The region of interest to this study is shown also in Fig. 6b and the aircraft picture and the particle counter graphic are of no special meaning to this work. I suggest the removing of graphic 6a.

Technical corrections:

P 2, L 3: “VATDM model “ -> the word model is part of the acronym

P 2, L 23: close bracket is missing

P 2, L 24: check spelling of the “atmosphere”

Chap. 2: check the spelling of “Eyjafjallajökull”

P 3, L 18: N for 70 degrees North is missing

P 3, L 21: check number of brackets

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P 3, L 22 and L 24: “information of“ -> information on

P 3, L 32: “The registration is needed.” -> Suggestion: Registration required

P 6, L 15: “have been” -> were

P 6, L 27: “has been” -> was

P 8, L 12: “around the Netherlands” -> above / in the area of the Netherlands

P 8, L 13: “mass loadings from EnSR is” -> mass loadings from EnSR are

P 9, L 3: check comma within the date

P 9, L 4: “Düesseldorf” -> Düsseldorf

P 9, L 7: “along the Dutch border” -> be more precise: Dutch-German border

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