Interactive comment on "Reconstructing volcanic plume evolution integrating satellite and ground-based data: Application to the 23rd November 2013 Etna eruption" *by* Matthieu Poret et al.

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Comments from an anonymous referee (Referee #2)

Overview

This manuscript (hereafter referred to as MS) presents a method to estimate the Total Grain Size Distribution (TGSD) of volcanic ash by combining field (ash deposits) and remote sensing data (radar, and satellites). The method is applied to the paroxysmal eruption of Etna volcano, Italy on 23rd November 2013. The resulting TGSD is then

used as input for a tephra dispersal model to reproduce the tephra loading and the far-field airborne ash mass. The results highlight the necessity of integrating the field and remote-sensing data (from different instrument) to achieve a better estimate of the initial TGSD, which is a key input parameter for modeling the ash dispersion and hazards. The study is novel and within the scopes of ACP. Indeed, the integrated approach introduced in the MS can lay the ground for developing new methods or tools to assess the full spectrum TGSD, which is very important to improve the ash dispersion modeling and volcanic hazard assessment. Although the methods and assumptions seem sound and valid, they are not clearly outlined. For example, the methodology is vague in some places (please see the general comments below). So, I recommend the MS for publication after addressing the following points.

General Comments:

1. In the methodology section the text is vague and hard to follow (especially P5L20-30, P6L26-42, whole section 3.3). It could be substantially improved. Moreover, there are several tuning parameters introduced in each section and used for specific purposes. Adding one table to show these parameters, ranges and purposes would be helpful.

Answer: Thank you for having pointed out the issues. We corrected the manuscript to help the reader to follow the flow being more concise and clear, especially the methodology section (p.4 - line 28). We also added a table (Table 2) to show the input parameters used within the numerical models.

2. The authors refer to very fine ash as PM20 based on Rose and Durant (2009), which is a mistake. Rose and Durant (2009) define PM30 as the very fine ash and not PM20. Authors should either justify the changes in the size range (reduced range to PM20) or redo the calculations using the correct value of PM30.

Answer: The introduction of the very fine ash was unclear. Although Rose and Durant (2009) define the very fine ash as PM30, here we refer to the PM20 for consistency with the satellite data. Considering the atmospheric residence time, the range reported

in Rose and Durant (2009) is still valid for PM20, being included within PM30. However, we corrected and referenced the use of the terms referring explicitly to PM20 in p.1 - lines 17-19.

3. There are references to unpublished (submitted) papers. I recommend removing these references.

Answer: Done.

4. In several locations (e.g. P4L23, P10L27), it is written that ice is released/emitted/erupted. Volcanoes never emit ice. They emit water vapor that is transformed into liquid water and ice due to microphysical processes. This could be seen also in Fig. 4 where ice formation starts later than SO2 and ash emission. Taking this into account, how would the interpretations change?

Answer: Thank you for having raised the confusion. We corrected the sentences in p.4 - lines 4-8 and p.10 - line 19. Obviously, we meant that ice was produced by the conversion of the water vapour that ascent up to the top of the volcanic column. The interpretations that the upper water (ice) rich part moved in a different direction of the lower part remain unchanged.

5. The 1D plume model FPlume is able to reproduce the ash to ice ratio during the plume evolution. It would be interesting to see how the FPlume modeling results compare with the values shown in Fig. 4 (ice/ash ratio could be calculated from this data). This is very important for model evaluation. Indeed, the authors take a primary input (TGSD) and then try to reproduce the very last outputs: deposition and airborne mass. This means they omit all the important factors and uncertainties that affect the plume rise and transport between emission and deposition (like the ash/ice ratio mentioned above or vertical distribution of the plume). These uncertainties and simplifications should be clearly explained and justified.

Answer: The FPlume model is used to describe the source in terms of tephra particle

released per unit of time at the scale of FALL3D grid, that is of a few kms. The focus is not to describe the microphysics of the column or the feature of the plume in the near field. The uncertainties related to these processes are dealt as uncertainties of the source term. A systematic parametric study about typical uncertainties in FPlume is presented in Macedonio et al., (2016). This was mentioned in the revised text (p.6 - line 9). This study aims at highlighting that a synergic use of different data permits reproducing simultaneously ground and airborne observations. Although uncertainties affecting the plume and tephra transport between emission and deposition exist, on the scale of our simulations, local plume dynamics and plume microphysics are not pivotal and our approach aims at constraining the plume height and MER by reproducing available field and airborne measurements. Factors that can affect plume at local scale (lower than FALL3D resolution considered in this study) should be investigated using more sophisticated models (e.g. Cerminara et al., 2016), not using simplified BPT models.

Specific comments

P1L02: do you mean "explosive volcanic eruptions"?

Answer: Yes, we corrected in p.1 - line 15

P2L05: replace automatic with automated.

Answer: Done (p.2 - line 5).

P2L08: By Making ...

Answer: Done (p.2 - line 8).

P2L41-P3L2: This belongs either to the abstract or conclusions.

Answer: Done. The sentences were modified and moved to the abstract (p.1 - lines 24-30).

P3L10: 17th episode in the history or in one specific duration?

Answer: The paroxysm is the 17th of the specific duration of 2013, as mentioned in p.3 line 2.

P3L16: "heavier" or denser?

Answer: Thank you for pointed out the confusing terms. The brownish cloud is denser than the water vapour cloud. We corrected the sentence in p.3 - line 8.

P3L17: Volcanoes do not emit any water/gas droplets. Water droplets and aerosols are indeed formed in the atmosphere.

Answer: The sentence was corrected in p.3 - line 9.

P6: What are the input parameters of FPlume (exit velocity, vent diameter etc)? Please explain.

Answer: The model FPlume, the assumptions, input parameters, and limitations are extensively described in other papers cited in the main text (Folch et al., 2016; Macedonio et al., 2016). As input, it needs the TGSD, the eruptive column height (or MER), initial ejection velocity, exit magma temperature, and water fraction at the vent. These points were better described and the section related to the use of FPlume improved (from p.5 - line 33).

P6L8: 2.5 wt% of what? Water?

Answer: The sentence was corrected (p.6 - line 1).

P6L13: This is not clear. Do you mean less that 2 wt% of the fine ash is removed by aggregation?

Answer: Yes, 2 wt% of the fines are removed by aggregation as described in Poret et al. (Under review). The sentence was modified to gain in clarity (p.6 - lines 6-8).

P8L23: what is the difference between RMSE1, 2 and 3? Please explain.

Answer: Thank you for having mentioned the issue. The difference between the RM-

SEs is related to the error distribution used within the calculation. The full description of the different RMSEs is available in Folch et al. (2010), although we modified the sentence in p.7 - lines 18-19.

Fig. 3: The quality is so low that the ash and ice plumes are very hard to recognize. Please use a higher resolution if available.

Answer: Thank you for having pointed out the lack of visibility. We modified the figure and hope the reader can appreciate the figure showing the dispersion of the ash and ice clouds.

Fig. 5: please clarify the difference between Whole TGSD and the integrated TGSD in the text.

Answer: The TGSD section (Sect. 3.1 in p.4 - line 34) was modified to improve the clarity about the difference between the TGSDs. In particular, the Integrated TGSD emerges from the weighting average combination between the field-derived TGSD and the X-Radar-derived TGSD. The Integrated TGSD is inverted by best-reproducing the tephra loading at the sampled sites (p.5 - lines 14-20). Then, the Whole TGSD is the empirical modification of the Integrated TGSD by adding very fine ash into the tail of the distribution to best reproduce the airborne ash mass retrieved from satellite (p.5 - lines 21-31).

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2017-1146/acp-2017-1146-AC2-supplement.zip

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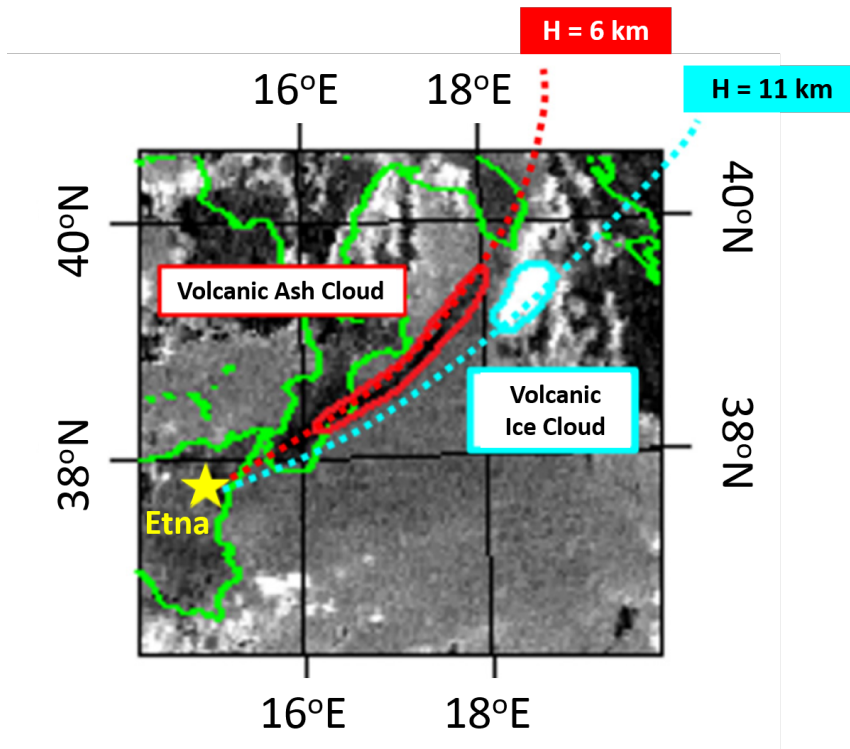
Fig. 1. Figure 3: Satellite image (SEVIRI) showing the trajectories of the two volcanic clouds (modified from Figure 17 in Corradini et al., 2016). The ash cloud dispersed towards the Puglia region (southern