

We thank the reviewer for the useful comments and suggestions and believe that now this manuscript has been significantly improved. Please, find hereafter our replies to all your comments highlighted in red, whereas all modifications in the main text are in yellow. Thank you for having considered this manuscript.

Dear editor,

in this contribution, Mereu et al. address the problem of estimating the load of tephra accumulated on roads as a consequence of explosive activity at Mt. Etna, Italy. The authors analyze data from 39 explosive events during 2021 in order to obtain a set of inputs to run numerical simulations with the widely used programs Tephra2 and Fall3D. Numerical results are post-processed taking into account the road network in order to quantify the mass of tephra accumulated on critical points around Mt. Etna (from a crisis management perspective). In general, the text is well-written, but some parts are a little bit redundant. On the other hand, a lot of data related to figures (e.g. color scales) are indicated in the main text, and I think they should be restricted to the caption. In addition, some redundant methodological explanations are included in the results section and is not always easy to follow the structure of the text. The state of the art and the addressed problem are introduced in the first section in a clear manner, and this problem is correctly addressed in the manuscript (although a few references are suggested below). The methodology is clear and responses to the introduced problem. Discussion and conclusions are effectively based on results, and presentation of results is accompanied by descriptive figures that effectively display the main results highlighted in the manuscript.

However, I would like to raise the following issues that I think must be addressed before publication:

1. I wonder how efficient is the clean-up of roads due to natural reasons (meteorological phenomena) and effects related to routine human activities (different from cleaning-up activities). The authors describe this point in L348-352 as a limitation of the adopted methodology. This is ok, but it is still critical, in order to understand the validity and significance of results, to have an idea of the order of magnitude of the “natural” clean-up velocity of roads, and thus a larger discussion about this point is needed. For instance, when we analyze the curves presented in Figs. 4 and 5, how are these slopes compared to the expected natural clean-up of roads? Are there differences in the natural clean-up velocity as a function of elevation or vehicles circulation?

>> We have stressed this point highlighting how a combination of different cleaning methods is necessary to speed up the ash removal from high priority routes used in the management of these crises.

2. How comparable are estimates of H_{TP} derived from XWR, ECV frames and SEVIRI data with respect to those computed from ENT images? Are there examples for which all the methodologies have been applied simultaneously?

>>>The H_{TP} estimate derived from different sensors (XWR, ECV frames, and SEVIRI) shows a time trend that is quite comparable to those described in previous works (e.g., Freret-Lorgeril et al., 2021; Scollo et al., 2019). The H_{TP} estimations are derived from the analysis of XWR observations, ECV frames, and SEVIRI data. Generally, the XWR estimates show values slightly lower than those derived from ECV and SEVIRI. This difference is due to the sensitivity limitations of XWR in detecting the finest ash particles at higher altitudes, compared to the other two sensors. In contrast, by analyzing the ENT images, whose field of view is mainly focused on the lower section of the volcanic plume (a few kilometers above the volcano vent) and not on the entire cloud, we identify the Incandescent Jet Region, which is considered a proxy for the lava fountain (Mereu et al., 2020).

Hence, this is not a direct measure of the H-TP but only of the mass eruption rate, having consequently higher errors.

3. In general, model limitations should be described better.

>> We have added some texts and references regarding the model limitations. Limitations, in fact, have been already analyzed in literature (Scollo et al. 2008B; Folch et al., 2012, 2016).

4. I identified the following citations issues:

a) In L80, is it Bonadonna et al. 2021a or 2021b?>>done

b) Bonadonna et al. 2023 is not present in the reference list. → Bonadonna et al., 2021a>>corrected

c) Guobadia et al. 2021 is not present in the main text. → Bonadonna et al., 2021a>>corrected

d) Macedonio and Costa 2012 is not present in the main text.>>cancelled

e) Pardini et al. 2023 is not present in the main text.>>this work is cited in par.3.1

All in all, I recommend publication of this manuscript in EGUSphere after minor but essential revisions. In the following lines, I include a set of detailed and editorial comments and suggestions. Please note that my mother-tongue is not English.

Alvaro Aravena

Detailed and editorial comments:

L13: I suggest to delete “, which can require a rapid clean-up”.>>done

L14: “reduce” > “evaluate and reduce”.>>done

L16: I suggest to delete “top”.>> it's the definition of acronym Top Plume Height H_TP

L18: I suggest to delete “this analysis”.>>done

L18: “mostly” > “significantly”.>>done

L20: “the volcanic ash radar retrieval approach able to retrieve” > “a volcanic ash radar retrieval approach that permits us to compute the”.>>done

L21: I suggest to delete “top”.>>as before

L21: “, grain size distribution of those events” > “and grain size distribution”.>>done

L21: “When the” > “When”.>>done

L24: “those” > “the computed”.>>done

L26: “allowing” > “allowing us”.>>done

L27: I suggest to delete “significant”.>>done

L28: I suggest to delete “and disposed”.>>done

L29: “quick planning and management” > “planning and quick management”.>>done

L29: I suggest to delete “possible”.>>done

L31-32: Please rephrase. “Quantification of data” is not a piece of information by itself. I think the phrase “of a specific intensity” is not necessary.>>corrected

L35: “poor visibility conditions” is not a problem by itself. I suggest to delete it and include the reference in the part related to “dangerous road conditions”.>>done

L48: “, to allow” > “and to allow”>>done

L52: I suggest to delete “try to”.>>done

L53: “Etna that were more affected” > “Etna, which were affected”>>done

L54-55: “hours and sometimes ... times a day” > “hours, separated by periods that can last from few hours to few days”>>done

L56: Please delete “generally”. The word “most” is already present.>>done

L58: “accumulation” > “tephra accumulation”.>>done

L61: “only to 39 events which” > “on 39 events that”.>>done

L63: “in” > “to”.>>done

L70: “those” > “these”.>>done

L71-72: Please define MER and HTP in the first mention.>>done

L73: I suggest moving some of the citations to the previous sentence (“... advection dispersion-models”), where you could include references of other diffusion-advection models that consider the same inputs. For instance:

- Tadini, A., Gouhier, M., Donnadieu, F., de’Michieli Vitturi, M., & Pardini, F. (2022). Particle sedimentation in numerical modelling: a case study from the Puyehue-Cordón Caulle 2011 eruption with the PLUME-MoM/HYSPLIT models. *Atmosphere*, 13(5), 784.

- Takishita, K., Poulidis, A. P., & Iguchi, M. (2021). Tephra4D: a python-based model for high-resolution tephra transport and deposition simulations—applications at Sakurajima volcano, Japan. *Atmosphere*, 12(3), 331.

>>We have modified and added the new references

And I suggest to keep the specific references associated with the presentation of the codes Tephra2 and Fall3D in the next sentence (“... such as Tephra2 and Fall3D”).>>done

L77: “and to assess uncertainties” > “and assess the associated uncertainties”.>>done

L80: 2021a or 2021b?>>corrected

L82: I suggest to delete “theoretically”.>>done

L81-90: I think parts of this paragraph are a little bit redundant. >>We simplified this paragraph

>>We have reformulated this paragraph, as highlighted in yellow in the main text

L94: “finally,” > “, finally,”.>>done

L94: “are in” > “are included in”.>>done

L101: “, Fig. 1” > “(Fig. 1)”.>>done

L106: “that is” > “calculated as”.>>done

L108-109: I suggest to delete “integrating the ... we retrieve”. Otherwise, the enumeration becomes strange.>>done

L110-112: I suggest to include the following reference (I am sorry for the self-reference):
Aravena, A., Carparelli, G., Cioni, R., Prestifilippo, M., & Scollo, S. (2023). Toward a real-time analysis of column height by visible cameras: an example from mt. Etna, in Italy. Remote Sensing, 15(10), 2595.>>We have added this reference

L116: “altitude derived” > “altitude, which is derived”.>>done

L124: “specific” > “the following”>>done

L132: “of which three of these under examination and” > “of which three are under examination, and”.>>done

L134: “symbol” > “symbols”.>>done

L138-139: “is derived ... previously described” > “is displayed in Table 1”.>>done

L139: I suggest to delete “Usually” if you use the expression “not always” in the same sentence.>>done

L140: “the plume” > “of plume”.>>done

L141: “derive” > “collect”.>>done

L141-143: I suggest to rephrase this part. >>We rephrased this paragraph
>>We have reformulated this part of text (highlighted in yellow) in the paragraph.

L151: “straight” > “straightly”.>>done

L151: “Qm estimates XWR-based” > “XWR-based Qm estimates”.>>done

L152: “time” > “and iii) time”.>>done

L153: I suggest to delete “iii)” and “iv)”.>>done

L156: So are the authors considering a constant wind field at different heights?>>done

L160: I suggest to delete “, as available in literature”.>>done

L162: “in the Table” > “in Table”.>>done

L168: I think the method used in each case to compute H_TP should be indicated. >> This point is described in points a)-i), b) and c) of par. 2.1.1

L176: “2005; Bonadonna et al., 2006;” > “2005, 2006;”>>done

L176: “input” > “inputs”.>>done

L177-180: I suggest to enumerate using ‘;’ instead of ‘,’ because you are also including some descriptions (and I would use ‘,’ to separate variables and their descriptions).>>done

L180: “the plume” > “and the plume”.>>done

L185: “from buoyant” > “from the buoyant”.>>done

L186: “cost in computational time” > “computational cost”.>>done

L190: “assuming a” > “assuming”.>>done

L190-191: I suggest to delete “In particular ... respectively”. This should be indicated in the caption.>>done

L192-193: I suggest to delete “Isomass ... 5 10³ kg/m²”. This should be indicated in the caption.>>done

L198: “The tephra” > “Tephra”.>>done

L202-203: “the geo-referenced ... on the ground” > “the geo-referenced data of tephra load on the ground in UTM coordinates ... resolution of 500 m”.>>done

L218-219: I would end the paragraph after “February 2021”. This should be indicated in the caption.>>modified

L230: I am not sure that “validation” is the correct word. I suggest “verification”.>>modified

L234: “; Table 2 shows also” > “, as well as the”.>>done

L235: “first” > “the first”.>>done

L239: “These” > “These discrepancies”.>>done

L241: “derived on 14 field data” > “on 14 sites”.>>done

L261: “equals” > “=”.>>done

L261: “greatest” > “their larger”.>>done

L271: I think this parenthesis is not necessary.>>done

L272: “specific” > “discrepancies in the”.>>done

L272: “It is worth noting” again is a little bit redundant.>>modified

L272-276: I did not understand this part. Please rephrase.>>modified

L280: “in the” > “is presented in the”.>>done

L284-286: Please rephrase (or delete). I think it is not needed to explain results and included in the introduction.>>This sentence has been modified and moved in the introduction

L286: “the Sicily” > “Sicily”.>>done

L288: “the east ... Etna flanks ... at south” > “east (31%), southeast (35%) and northwest (29%), and only 6% towards south”.>>done

L289: It this consistent with wind data in the Etna zone during the last decades?>> We stressed this point in the main text (Scollo et al., 2013; Barsotti et al., 2010). Generally the direction of the wind

disperses the volcanic plume towards the east and south. In this analysis we use the data derived from the ECMWF-Ara5 Reanalysis for more reliable information for Etna events.

L289-293: I think this is a methodological explanation.>>We have modified this sentence which is preparatory to Figure 5.

L295: “Each ... symbol” should be in the caption.>>modified

L296: “Obviously” > “Obviously,”.>>done

L300: “contrast with” > “contrast to”.>>done

L314: “is constant” > “stabilizes”.>>done

L317: “to the” > “due to”.>>done

L332-333: Please rephrase.>>done

L341: “lava fountains” > “explosive events”.>>done

L345: “greater” > “larger”.>>done

Table 4: I would combine the cells “39 Etna lava ... 2021” and “Location”, and call it “Location”.>>modified

L358: I suggest to delete “what is shown in”.>>done

L365: “assuming a” > “assuming”.>>done

L374: “2021 and” > “2021, and”.>>done

L382: “eruptions” > “eruption(s)”>>done

L383: I suggest to delete “the year”.>>done

L387: “; at” > “. At”.>>done

L389-390: This is a very interesting point that should be highlighted in the introduction, for instance.>>We have highlighted this point also in the introduction.

L393: I suggest to delete “, focusing on the ... municipalities”.>>done

L401: “intrinsic” > “different sources of”.>>done

L401: “data to” > “data, and due to”.>>done

L403: “mainly due both” > “related”.>>done

L409: 2021a or 2021b?>>done

L409: Bonadonna et al. 2023 is not present in the reference list.>> corrected: Bonadonna et al., 2021a

L432: Different reference formats are present. Please unify them.>>done

L441-442: This reference does not follow alphabetic order.>>done

L498: Guobadia et al. 2021 is not present in the main text.>> corrected: Bonadonna et al., 2021a

L542-543: Macedonio and Costa 2012 is not present in the main text.>>cancelled

L544-545: Pardini et al. 2023 is not present in the main text. >>This work is in par. 3.1

L579-580: This reference does not follow alphabetic order.>>done

L581-582: This reference does not follow alphabetic order.>>done. We have verified all the references and alphabetically ordered.