

# Reply to Reviewer 1

UAV survey method to Monitoring and analysing geological hazards: The Case study of mud volcano of Villaggio Santa Barbara, Caltanissetta (Sicily)

Fabio Brighenti et al.

A pdf file of the reviewed manuscript is attached as supplement file. The changes in the text are marked with **green** for rephrasing, reorganised and new parts added, and with **yellow** the changes suggested by the referees.

## 1. General Comments

Hereby I want to state that I reviewed this manuscript to my best ability and approached it with interest and with the intention to give suggestions which improve the quality of the work. The methods used in the paper are interesting and relevant for future studies in order to optimize SfM methods for ground deformation analysis and monitoring. However, the paper needs reorganization, clarification and rephrasing. I want to address that the presented manuscript does not contain a Results chapter but instead goes directly from Methods to Discussion. However, the results of the study are presented in both Methods and Discussion. This makes the article confusing and resulting data unclear. I would strongly recommend a reorganization of the content with a clearer separation between Methods, Results and Discussion. Doing this will increase the readability of the work significantly. Furthermore, the first paragraph of the Conclusion would make more sense in the Introduction chapter. I would as well strongly recommend having this paper proof-read by a native English speaker before the next submission to correct and improve the phrasing. The sentence structure is sometimes too complicated or incorrect so that I think the paper quality would largely benefit from having it proof-read.

*Reply: Thank you for your interest in understanding and helping us with the paper. We want to thank you for your kind advices. The paper has been reorganised; the chapter Results has been added. The paper now follows the order of the chapters Methods, Results and Discussion. The data has been reordered within the Results chapter. Large parts of the paper have been reorganised, clarified and rephrased. The first paragraph of the Discussion has been moved to the Introduction. The paper has been corrected by a native speaker.*

## 2. Specific Comments

### Abstract

Line 12- 15: "Among all the active geological processes on Santa Barbara mud volcano (Caltanissetta town, Italy), represents a dangerous site because it caused, on 11 August 2008, a paroxysmal event, which determined severe damages to the infrastructures at around to 2 km the paroxysmal event." Confusing - rephrase this sentence.

*Reply: The sentence has been rewritten (Line 15-17).*

## **Introduction**

Line 40 – 44: “The accuracy of 3D information can be significantly increased by the ground control points (GCPs) by georeferencing the data to ground control points (GCPs). The GCPs acquisition acquisition is a undamental fundamental aspect of the georeferencing of the network of images captured by UAV photogrammetry – unclear phrasing. Images are not captured by UAV photogrammetry. Images are captured “for photogrammetry” or “by UAV”. “In this process a right number of GCPs is required which lead to a greater accuracy of the outcomes (point clouds, 3D grid, orthomosaic or digital surface model (DSM)).” - rewrite these sentences more concise without repetition. e.g.: "Ground control points (GCPs) are used to improve the accuracy of the resulting data. Therefore, points recognizable on the UAV imagery are measured with a survey device to georeference the data."

*Reply: The sentences were rewritten and clarified (Lines 53-54).*

Line 46: “In this paperthrough SfM, . . .” - what do you mean? As well use a consistent acronym for SfM

*Reply: There was a typo in the sentence. The acronym is inserted (Line 20).*

Line 70 – 73: “This morphometric structure is typical of uplifting areas and therefore relative decrease of the base level. This morphometric evidence suggests uplift processes- repetition of the canopy volcano area- what is that?? that lies above a stagnation chamber that has been carried out for this research project through geophysical investigation- confusing, rewrite this sentence.”

*Reply: The sentences were rewritten and clarified (Lines 83-85)*

## **Methods**

Line 98: Figure 3 Incomplete Legend -what are the other colors and symbols in the map? -probably choose different background map. -what is the CRS /grid?

*Reply: The legend has been maintained. The base map has been changed (Line 110).*

Line 117-119: “During the monitoring sessions there has been ongoing research on the best Ground Control Points (GCPs) methods of acquisition. This was aimed at a more detailed indication of the 3D deformation process of the volcanic cap and a vertical and horizontal geometrical resolution of centimetre/subcentimetric order of magnitude.” – confusing. Rewrite those sentences.

*Reply: The sentence has been clarified and rewritten (Line 129-130).*

Line 116 and onwards: Ground Control Points (GCPs) Please explain the different errors you mention and how they are calculated. Explain “error”, “total error”, “GCP error” and “average total 3D error” As well clarify for the reader what the difference between “GCPs”, “Control Points” and “Checkpoints” are.

*Reply: The error is calculated by Photoscan, through the mean square deviation of the distances of the CheckPoints with the point cloud. A description of the*

*different types of errors has been added (Line 131-134). A definition of GCPs, Control Points and Check Points has been added (Line 171-176).*

Line 122: “10-1:10-2 m”- please clarify what this means

*Reply: Typing error has been corrected (Line 132)*

Line 127-128: confusing, statistical analysis of what? The whole sentence should be clarified.

*Reply: We meant: statistical error analysis. The sentence has been clarified and rewritten. (Line 142-144)*

Line 129-130: “Since 2019 only TST has been used for the GCP survey and according to Tahar et al. (2013) the number of GCPs has been increased (Tab.1) reducing the error to  $\approx 1.4$  cm and in the last campaign  $\approx 0.7$  cm.” -are you saying the increase of the GCPs has reduced the GCP error or the fact that only TST was used for the survey? please clarify.

*Reply: The joint application of more GCPs with the use of TST reduces the error (Line 144-146).*

Line 131: “. . .greater control..”- what do you mean by that? – higher accuracy?

*Reply: We meant more accurate geometry reconstruction of the models produced by SfM. The sentence was deleted.*

Line 131: “. . . limit number. . .”- explain what you mean by this.

*Reply: We meant: increasing the number of GCPs. The sentence was deleted.*

Figure 4: it would be beneficial to have a relative scale of the horizontal error below the green ellipse e.g.: (in X- direction) or something similar.

*Reply: In figure 4 the scale has been improved as suggested*

Line 151-152: “Photoscan accuracy” – what do you mean? The accuracy of the resulting data? Clarify

*Reply: “Photoscan accuracy” is the term used by the Photoscan software to refer to instrument precision. This sentence has been rewritten and clarified (Line 166).*

Figure 6: what do red and blue mean?

*Reply: Red are the Control Points. Blue are the Checkpoints Control Points. The figure has been moved on figure 12.*

Line 164-165: “25° to 75° percentile” – do you mean 25th to 75th percentile?

*Reply: Of course, it was a typing error (Lines 286-287).*

## **Photo Acquisition**

Line 173-174: "The camera was oriented in a 90- degree angle"- can be confusing for the reader. Say that "vertical imagery" was acquired

*Reply: We agree, the sentence has been rewritten (Line 186-187).*

Line 174: explain what a single grid is.

*Reply: We have added the explanation of single grid (Line 187-188).*

Line 174: Introduce the acronym (ground sampling distance)

*Reply: We have added the explanation of single grid (Line 188).*

## **Data Processing SfM**

Line 189-190: "value" doesn't seem the right term here. Rather use step/s of the processing chain

*Reply: we followed the suggestion (Line 192).*

Line 203: "measurements of check" -checkpoint measurement??

*Reply: We meant measures applied to each image and checkpoint (Line 212-213).*

Line 215: which version of Cloud Compare?

*Reply: The version is v. 2.11 (Line 231).*

Line 219-220: "This methodology has been chosen having in mind the heterogeneous distribution of the points in the sparse cloud, avoiding holes and thus null values." - is this why you chose this interpolation method or is it just something you keep in mind? - clarify and replace the term "having in mind" with something more precise. eg.: "This method has been chosen "because of"/ "due to" the heterogeneous distribution...."

*Reply: - Yes, that is why this method of interpolation was chosen. We followed the suggestion by rewriting the sentence (Line 235-236).*

Line 221: which "measurements" do you mean?

*Reply: we meant comparison surveys (Line 244).*

Line 223-224: it would be beneficial to include an illustration of a precision map.

*Reply: Illustrations of precision maps and precision maps interpolated with the dense point cloud have been added (Line 222-227 and line 235 and line 238-241).*

Figure 9: Numbers on legends too small

*Reply: The scale numbers have been enlarged and the figure has been moved to figure 10.*

Figure 11 and Line 264-265: "These were used to have an instrumental sensitivity scale of the measures of figure 12. The first and lowest one (~2 cm) was easily detected." - what about the others? up to 10 cm? or are you saying that if only one is easily detected the others are not necessary. If you are not going to talk about the other calipers it should be considered whether figure 11 is necessary.

*Reply: All calipers have been recorded but we have put the smallest as an example on the text. Fig.11 has been deleted following your suggestion (Line 265-268).*

### **Discussion**

Line 289: "...temporally distant peaks...." – clarify what you mean by this? Data sets?

*Reply: We meant: the greater temporal distance of the data. The sentence has been rewritten (Line 314-315).*

Line 299: clarify in the caption which M3C2 distance is shown here (between which datasets) - explain what processes lead to the M3C2 distance around the edges of the survey area? or is this due to lower precision and/or accuracy in these areas?

*Reply: - The data used has been explained more clearly. We assume that the increase in distance at the edges is mostly due to material deposition (Line 321-323).*

Figure 15 and 16: add error bars to the time series. Increase the size of the font on the scale

*Reply: Error bars have been added. The font has been enlarged. The figures have been renumbered to 16 and 17 (Line 338 and 351).*

### **Conclusion**

Line 330-341: this paragraph and references should be part of the introduction.

*Reply: We agree, the paragraph has been moved to Introduction (Line 25-37).*

Line 351: clarify what kind of interval you mean by "between 30 and 60 g"

*Reply: We meant an interval of 30 to 60 days to carry out a new survey. The sentence has been rewritten and clarified (Line 407).*

Line 352-353: What does this mean for other projects? Is this amount of GCPs scalable for different area sizes?

*Reply: This study can be useful for other projects, not in terms of the number of GCPs but in terms of methodology.*

### **3. Technical Comments**

Here are I point out minor technical suggestions with the same color coding as before.

Line 1: write “monitoring” with lower case m

*Reply: Has been changed to lower case (Line 1).*

Line 2: “the case study of “a”/”the” mud volcano

*Reply: “The case study of the mud volcano” (Line 2).*

Line 16: replace “danger” with “hazards”

*Reply: Has been changed (Line 14).*

Line 18: “for monitoring of deformation processes. . .”

*Reply: Has been added (Line 18).*

Line 21: Introduce abbreviation SfM

*Reply: the abbreviation has been added (Line 20).*

Line 34: “The different acquisition methods. . .”

*Reply: It has been deleted (Line 47).*

Line 35 - 36: “In this context, UAVs therefore offer unprecedented spatial and temporal resolution. . .” - repetition of the previous sentence.

*Reply: The sentence was rewritten (Line 47- 48).*

Line 38: “. . . .Lidar, thermal imaging cameras,. . . .” – add the comma

*Reply: Comma was added (Line 50)*

Line 44: “. . . is also affected by other features, for example. . .” –insert: controlled by other variables, such as:. . .

*Reply: The suggestion has been followed and the sentence has been rewritten (Line 55).*

Line 44 -45: “design and altitude of the flight” flight path and flight altitude

*Reply: The suggestion has been followed and the sentence has been rewritten (Line 56-57).*

Line 48- 49: 95% (LoD 95%) Level of Detection - 95% Level of Detection (LoD 95%)

*Reply: The sentence has been rewritten (Line 61-62).*

Line 55: "Ortho-photos generated by UAVs in the area of the Santa Barbara mud volcano."- Ortho-photo of the Santa Barbara mud volcano generated from UAV imagery

*Reply: The sentence has been deleted and the figure has been changed (Line 67).*

Line 58: ". . .developed since Late Miocene until the Quaternary" – ". . .which developed from the Late Miocene to the Quaternary, . . ."

*Reply: The sentence has been rewritten following the suggestion (Line 70).*

Line 59: ". . .formed by a foreland fold and a thrust belt. . ."

*Reply: Indefinite articles have been added (Line 71-72).*

Line 60: ". . .the clastic sediments deposited. . ."- ". . .the deposition of clastic sediments. . ."

*Reply: The sentence has been rewritten following the suggestion (Line 73).*

Line 60-61: ". . .during the late Miocene towards the Pleistocene. . ."- from the late Miocene to the Pleistocene

*Reply: The sentence has been rewritten following the suggestion (Line 73-74).*

Line 65: "On the mud volcanoes. . ."- which mud volcanoes??

*Reply: Examples of mud volcanoes have been added (Line 77).*

Line 62: "More hover. . ." ?

*Reply: Typing error (Line 80).*

Line 73. Personal communication with who? Which methods were used?

*Reply: The personal communication was given by a colleague, he was quoted (Imposa et al., 2018), they applied tomography techniques (Line 85-86).*

Line 73: "sill-like"

*Reply: The word has been replaced (Line 86).*

Line 74: replace develops with "sits" or "is located"

*Reply: The word has been replaced with "is located" (Line 85).*

Line 74: 50 meters

*Reply: The word has been added but with "m" (Line 86).*

Line 81: "On the surface outcrops deformation structures . . ." – rewrite

*Reply: The sentence has been rewritten (Line 94).*

Line 82-83: ". . . highlighting what high intensity of stress and strain the volcano can generate. . ." ... highlighting the high stress and strain environment .....

*Reply: The sentence has been rewritten (Line 95)*

Line 84-85: ". . .and we still believe they are active. . ." .... and are still believed to be active,

*Reply: The sentence has been rewritten (Line 96).*

Line 91: monitoring – monitor

*Reply: The word has been replaced by monitor (Line 103).*

Line 113: introduce acronym for TST

*Reply: The acronym has been introduced (Line 106).*

Line 113: ". . .TST base local station. . ." – local base station / local TST base station???

*Reply: The sentence has been rewritten (Line 106-107).*

Line 120: Real Time Kinematics (RTK)

*Reply: The acronym has been added (Line 130).*

Line 121: GCPs

*Reply: Has been corrected (Line 131).*

Line 121: ". . .(Tab. 2).. ." – do you mean Table 1??

*Reply: Yes I do (Line 132-133)*

Line 125: "detected"- "measured"

*Reply: The word has been changed by "measured" (Line 141).*



Table 1: "GCPs NUMBER" – GCP NUMBER

*Reply: We followed this suggestion*

Line 135: ". . .on the table. . ." – in the table

*Reply: The caption has been rewritten (Line 149).*

Line 141: rephrase the sentence.

*Reply: The sentence has been rephrasing (Line 156-157).*

Line 152: ". . .CTN1 points coordinates. . ."

*Reply: The correction has been performed (Line 178).*

Line 175: ". . . a cheap UAV.." – redundant information. Rather mention that it is a quadcopter UAV

*Reply: The suggestion was implemented (Line 183).*

Line 175: ". . . Fly flight altitude. . . ."

*Reply: The word has been replaced (Line 183).*

Line 176. "The feature of. . ."- feature is the wrong term here. Just say: The sensor size is. . . .

*Reply: The suggestion was implemented (Line 184).*

Line 193: add "" to the Gradual Selection

*Reply: The quotation marks has been added (Line 198).*

Line 196-197: James, et al. . . . .

*Reply: Has been corrected (Line 218).*

Line 210: "Secondly, . . ." where is the firstly??

*Reply: There is no firstly, the sentence has been rewritten (Line 219).*

Line 248: significant change

*Reply: Letters have been replaced (Line 304-305).*

Line 275: ". . .survey techniques, they have a very. . ."

*Reply: The sentences has been rephrased (Line 289).*

Line 289: "We....."

*Reply: The sentence has been rewritten (Line 316-318).*

Line 290: "Data are still. . . ." - "The data is still . . . ."

*Reply: The sentence has been rewritten (Line 316-317).*

Line 294: "In literature. . ." – "According to literature. . ."

*Reply: The sentence has been rewritten (Line 395-396).*

Line 360: "In this case more thoroughly monitoring will carried out:.. ."- rewrite this sentence.

*Reply: The sentence has been rewritten (Line 416-418).*

## Reply to Reviewer 2 RC2

UAV survey method to Monitoring and analysing geological hazards: The Case study of mud volcano of Villaggio Santa Barbara, Caltanissetta (Sicily)

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The list of references in the introduction section must be updated with recentmost researches (2018-2020), they are many.

*Reply: We have followed the suggestion. The bibliography has been improved, including papers from 2018 to 2021.*

The text regarding the GCP in the section must be moved to the methods.

*Reply: The text concerning GCPs has been moved to the methods chapter.*

Figure 1 show the orthomosaic resulting from photogrammetry processing. It can be moved to the results section. A geological introduction to the area is mandatory.

*Reply: We have substituted Figure 1 with an aerial photo of the study area. The geological introduction is present in the text.*

Report the reference system in all figures.

*Reply: The reference system has been added to all figures.*

There is a lack of references in the methods as well as there is a lack of details regarding the processing. I suggest reading recentmost papers focusing on the methodology.

*Reply: The chapter of methodology was improved and clarified through rephrasing and the addition of the Results chapter. The bibliography has been enhanced.*

It has been generated a DSM (Digital surface model) not a DEM.

*Reply: The acronym DEM is not present in the paper.*

Conclusion must be rewritten removing the lines listing several references that can be added to the introduction section. Conclusions must address the main results from the present work.

*Reply: The conclusion has been rewritten. The paragraph with the long list of references has been moved to the Introduction chapter.*

## Reply to Reviewer 2 RC3

UAV survey method to Monitoring and analysing geological hazards: The Case study of mud volcano of Villaggio Santa Barbara, Caltanissetta (Sicily)

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I suggest an improvement for the literature, some recent and important paper are missing.

*Reply: We have followed the suggestion. The bibliography has been improved, including papers from 2018 to 2020.*

The methodology must be improved, both regarding the UAV survey and SfM processing.

*Reply: The chapter of methodology was improved and clarified through rephrasing and the addition of the Results chapter.*

Figure 1 cannot be the Orthomosaic resulting from processing, it is a result

*Reply: We have substituted Figure 1 with an aerial photo of the study area.*

Conclusions must be rewritten avoiding the long list of citation.

*Reply: The conclusion has been rewritten. The paragraph with the long list of references has been moved to the Introduction chapter.*

Add the reference system in all figures.

*Reply: The reference system has been added to all figures.*