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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Brief communication: Remotely piloted aircraft systems for rapid emergency response: road exposure to rockfall in Villanova di Accumoli (Central Italy)" *by* Michele Santangelo et al.

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This document contains a point-to-point answer to the comments of reviewer #1. Reviewer comments (RC) are reported. Responses (AR) follow each RC. Quotations from the manuscript are in italics between inverted commas.

ANSWERS TO REVIEWER 1

RC: The paper focus on the analysis of the earthquake-triggered rockfall that occurred along the SP18 in Villanova di Accumoli (Lazio, Central Italy) during the 24 August

2016 seismic sequence. The Authors have used a Remotely Piloted Aircraft System for the acquisition of an image sequence to produce digital models and orthophotographs of the topographic surface with a final aim of identifying and characterizing the source areas of unstable blocks. Then, a detailed modelling of the potential rockfall trajectories allowed them to map the rockfall hazard and to assess the related risk. Results showed that only a part of the road hit by the rockfall can be exposed to further rockfall impacts Discussion paper and a limited part of the simulated trajectories reaches or crosses the road. Based on these data, limited protection measures were suggested. The topic of the paper is very interesting since the use of Remotely Piloted Aircraft System for the acquisition of data to model the topography, to identify the rocky unstable blocks and to simulate the potential fall trajectories plays an important role in rockfall risk assessment and in protection measures choice. I appreciated it. Maybe an additional RPAS flight with photos taken orthogonally in respect to the slope face could have allow a better identification and characterization of rocky unstable blocks and source area for rockfall modelling.

AR: We thank the reviewer for the effective description of our paper. In the paper we present the first results of a possible emergency response to a rockfall event. We know that an identification of rock joints is possible using an oblique acquisition of RPAS images. In another study we also performed this approach but in this case the focus was the definition of a short sequence of actions that ca be done to achieve a first result.

RC: The research design is anyhow quite appropriate. The interest to the readers is good but I want to underline that Authors have data to re-submit the paper in an improved form. The English language and style are in general appropriate. In general, the figures are simple, quite clear, properly cited in the text even if they present some errors (Please, see additional comments in the attached *.pdf file).

AR: We thank the reviewer for the suggestions that have been deeply analyzed before improving the text accordingly.

RC: Nevertheless, several weak points are present. The accuracy of DTM below the trees is the most critical part of the research: if the DTM has a low accuracy still has a real meaning the modelling of rockfall in STONE?

AR: We acknowledge that the final topography under the trees canopies is not as accurate as the areas free of vegetation, and according to the reviewer 2 we added a sensitivity analysis where we analyze the effect of the errors in the topography on the trajectories. This does not solve the issue of having a coarse DTM under the trees, but this is the best result that was possible to obtain in short planning and execution time during a seismic crisis. The question then would be if, given the existing technologies and knowledge, it is even possible at all to provide an (even coarse) answer to Civil Protection agencies. In this paper we maintain that it is possible, keeping in mind that there is uncertainty and error, which is always the case in any robust scientific approach.

RC: Why do the Authors not have measured additional and more accurate GPS points in a different manner? Why not using a Total Station to increase the GCPS number and their spatial accuracy?

AR: We use the only possible solution for a rapid acquisition of GPS points, which is RTK. We would like also to point out that the risk of possible new earthquakes was high and so we had to consider the possibility of new rockfalls. For this reason, we limited our exposition to risk and we avoided GPS static acquisition. The use of total station was also not feasible due to the strong vegetation.

RC: An alternative to this could has been to fly in autumn or at the end of winter time in such a way to have a reduced vegetation cover. By this way, for sure, the efficiency of the RPAS flight could has been greater even if the value of immediacy with respect to the emergency would have been lost.

AR: The choice of the winter period is absolutely a good idea for an improvement of the DSM quality, but the emergency condition did not allow such a strong delay.

RC: This last sentence links to another weak point: Authors declared that none of the published papers, to the best of their knowledge, focus on “testing a procedure that guarantees semi-quantitative information in a relatively short time to provide an evaluation of the residual rockfall risk during emergencies, when time and budget constraints are restrictive”. Before the Conclusions the Authors affirm that the entire procedure was estimated in about 15 working days of one person which is trustworthy but I wonder if does respond to the emergency times. If not, the presented procedure is correct but not very original and it limits itself to a common application of rockfall studying and modelling as several papers already do. Within the paper Authors affirm that the RPAS flight was done on October 10, 2016 while the earthquake is dated August 24, 2016.

AR: We acknowledge that this point was not made really clear. In the text we state that the total amount of work can be measured in 15 working days of one person, which does not mean that the application of the procedure took 15 days. In the text (P10 L29-30) we added the following text: "The entire procedure was carried out in 4 working days (estimated in about 15 working days of one person)". About the date of the flight compared to the date of the first seismic shock, in the Introduction (page 4, line 11) we wrote the following text: “In 2016, central Italy was affected by a very long and severe seismic sequence that began on August 24th with a MW 6.0 earthquake, followed by a second main shock on October 26th (MW 5.9), and third on October 30th (MW 6.5). The seismic sequence, characterized by more than 50,000 aftershocks in four months, triggered numerous rockfalls that caused damage to roads.”

RC: Additional remarks: The spatial accuracy of GCPs measured by GNSS RTK VRS method, is low (about 10 cm) when usually, using that methodology, a spatial accuracy lower than 5 cm for a single point is achievable.

AR: We agree with the reviewer, the resolution of GPS RTK can achieve 5 cm. in this case the presence of vegetation reduced the accuracy of several points. For this reason, we declared a precautionary value of 10 cm.

RC: The back analysis of the rockfall modelling (i.e. calibration phase) is missing and it could have allowed to improve the trustworthiness of results. Rockfall data calibration is routine in such applications, and in scientific papers is necessary. Moreover, Authors have data to do it on the basis of the earthquake-triggered rockfall of the 24 August 2016 seismic sequence.

AR: If here back-analysis means a systematic reconstruction of the trajectory of individual boulders found in the field, it was not performed due to lack of sufficient field data and because modelling along a single trajectory has not been performed in the analysis. On the other hand, a calibration of the parameters was performed based on the literature, field and remote sensing observations, and on our experience in order to obtain the most reasonable results.

RC: A geological map, that would have been useful, is also missing.

AR: The scale of the available published geological map is 1:100,000, which is quite disproportionate compared to the extent of the study area. That is why we did not add a geological map since it was not really useful to the understanding of the paper. We still maintain this idea. Given its scale, the readability of the area would require to add a figure to the paper, going beyond the requirements of a brief communication, and not really improving the readability of the paper.

Attached is a figure (Figure 1) that contains an excerpt of the available geological map. The red circle locates the study area, whereas the white polygons is the portion of the road that was studied.

RC: Finally, Highlights and Keywords, maybe not required for a Brief Communication of NHESS, are missing.

AR: We have checked the NHESS instructions for authors, and they are not yet required, at least at this stage of the manuscript preparation.

Attached is an annotated pdf where the comments of the two reviewers where merged

and responded point-to-point. Reviewer comments are colour coded.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-177/nhess-2018-177-AC1-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2018-177, 2018.

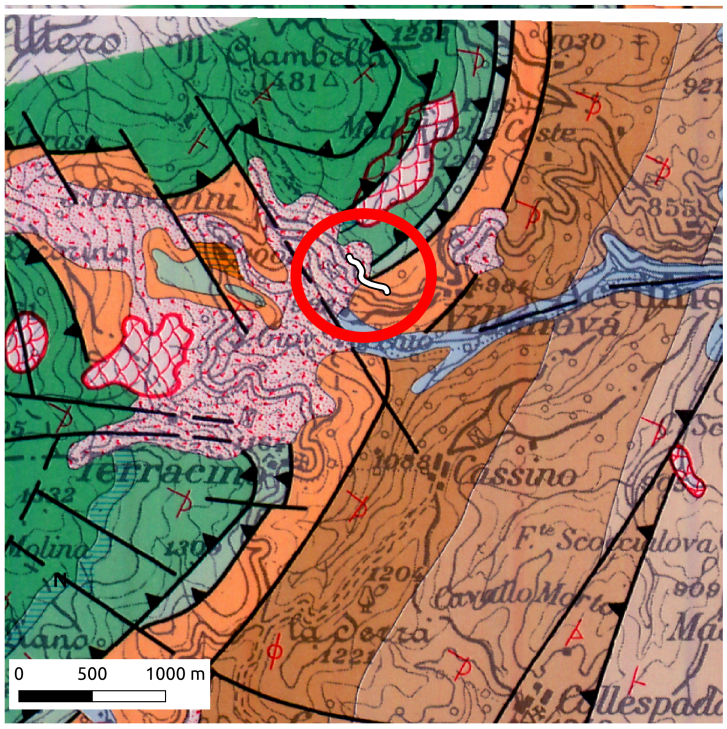
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Fig. 1.