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Discussions

Interactive comment on "Review article: The use of remotely piloted aircraft systems (RPAS) for natural hazards monitoring and management" *by* Daniele Giordan et al.

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Answer to Referee comments 1

RC - Referee comments AC- Author comments

RC - Overall This is a review paper relating to the use of RPAS for natural hazard monitoring and management. It particularly focusing on the use of Mini and Micro RPAS for five kinds of disaster, such as landslides, floods, earthquakes, wildfires and volcano activities. However, the topic and discussed disaster types are similar to the following paper just published last year. Thus, I suggest to major revise this manuscript.

AC - We would like to thank the Reviewer for his suggestions. We well know that the topic has also been analyzed by other authors. However, with our review, we tried to make the literature review more complete and updated. We provided more than 150 references considering the most important natural hazards, including some recent articles published in the last year and following the available Annual Disaster Statistical Review. Along these lines, we believe that the natural hazards scientific community will be benefited by such long and updated list of articles and research advances. In detail, the manuscript is focused on the revision of available bibliography for the use of RPAS for: landslides, earthquakes, volcanic activity and wildfires. These four categories are the most dangerous and the manuscript propose a revision of case studies and proposed methodology to fix a possible approach for the use of RPAS in these critical conditions. The description of case studies and possible approaches is important to fix a common methodology that can be used not only for scientific purposes, but also for the management of real emergencies. Until now, the lack of a well-defined methodology that describes pros and cons to the use of RPAS for the support during natural hazard emergencies is a critical aspect that this paper can try to solve.

RC - Detail comments are stated below. ï ËŻAn Christopher Gomez and Heather Purdie, 2016, "UAV- ËĞ based Photogrammetry and Geocomputing for Hazards and Disaster Risk Monitoring – A Review", Geoenvironmental Disasters, Vol.3, No.23. 2. Comments i. The above mentioned article was not referenced, compared or analyzed. It is strongly suggest to include this paper and conduct comparisons to emphasize their different point of view.

AC - Line 132: Done. We would like to thank the Reviewer for this suggestion. We added this important paper in our review, and we also considered the bibliography of the manuscript. In our manuscript, we revised 151 papers (92 more than the paper mentioned above) that can be considered an exhaustive representation of available bibliography on this subject. With respect to Gomez and Purdie (2016), we tried to analyze more in-depth the bibliography and define a possible methodology for the use of RPAS that we obtained merging all the revised papers. In the case of landslides, for example, this approach has been used to define the possible use of RPAS for: i) landside recognition, classification and post-event analysis, ii) landslide monitoring, iii) landslide susceptibility and hazard assessment. For each of this points, we present a description of the use of RPAS based on the available bibliography. To clarify this point, we add the following paragraph that introduces the paper of Gomez and Purdie and points out the different approach of our manuscript: "Gomez and Purdie (2016) published a detailed analysis of the use of RPAS for hazards and disaster risk monitoring. In our paper, we focused our attention on the most dangerous natural hazards that can be analyzed using RPAS. According to the definitions used by Annual Disaster Statistical Review (Guha-Sapir et al., 2016), the paper considers in particular: i) landslides, ii) floods iii) earthquakes v) volcanic activity vi) wildfires. For each considered category of natural hazard, our paper presents a review of a large list of published papers (151 papers) analyzing proposed methodologies and provided results, and underlining strengths and limitations in the use of RPAS. The aim of this paper is the description of the possible use of RPAS in considered natural hazard, describing a general methodology for the use of these systems in different contexts merging all previously published experiences." In this revised version of the paper, we also added the following bibliography: Derrien, A., Villeneuve, N., Peltier, A. and Beauducel, F.: Retrieving 65 years of volcano summit deformation from multitemporal structure from motion: The case of Piton de la Fournaise (La Réunion Island), Geophys. Res. Lett., 42(17), 6959–6966, doi:10.1002/2015GL064820, 2015. Dewitte, O., J.C. Jasselette, Y. Cornet, M. Van Den Eeckhaut, A. Collignon, J. Poesen, and A. Demoulin.: Tracking landslide displacements by multitemporal DTMs: A combined aerial stereophotogrammetric and LIDAR approach in western Belgium. Engineering Geology, 7, 582–586, 2008. Diaz, J. A., Pieri, D., Wright, K., Sorensen, P., Kline-Shoder, R., Arkin, C. R., Fladeland, M., Bland, G., Buongiorno, M. F., Ramirez, C., Corrales, E., Alan, A., Alegria, O., Diaz, D. and Linick, J.: Unmanned Aerial Mass Spectrometer Systems for In-Situ Volcanic Plume Analysis, J. Am. Soc. Mass Spectrom., 26(2), 292–304, doi:10.1007/s13361-

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2015. Guha-Sapir, D., Hoyois, P., and Below, R.: Annual Disaster Statistical Review 2015 The numbers and trends. Centre for Research on the Epidemiology of Disasters, Ciaco Imprimerie, Louvain-la-Neuve (Belgium), pp. 50, 2016. Hervouet, A., Dunford, R., Piégay, H., Belletti, B. and Trémélo, M.-L.: Analysis of Post-flood Recruitment Patterns in Braided-Channel Rivers at Multiple Scales Based on an Image Series Collected by Unmanned Aerial Vehicles, Ultra-light Aerial Vehicles, and Satellites, GIScience Remote Sens., 48(1), 50–73, doi:10.2747/1548-1603.48.1.50, 2011. Javernick, L., Brasington, J. and Caruso, B.: Modeling the topography of shallow braided rivers using Structure-from-Motion photogrammetry, Geomorphology, 213, 166–182, doi:10.1016/j.geomorph.2014.01.006, 2014. Lindner, G., Schraml, K., Mansberger, R. and Hubl J.: UAV monitoring and documentation of a large landslide. Appl Geomat, 8(1), 1-11, 2016. Liu, C.-C., Chen, P.-L., Tomoya, M., Chen, C.-Y.: Rapidly responding to landslides and debris flow events using a low-cost unmanned aerial vehicle. J. Rem. Sens. 9(1), 1-11, doi:10.1117/1.JRS.9.096016, 2015. Mori, T., Hashimoto, T., Terada, A., Yoshimoto, M., Kazahaya, R., Shinohara, H. and Tanaka, R.: Volcanic plume measurements using a UAV for the 2014 Mt. Ontake eruption, Earth, Planets Sp., 68(1), 49, doi:10.1186/s40623-016-0418-0, 2016. Nakamura, F., Shimatani, Y., Nishihiro, J., Ohtsuki, K., Itsukushima, R. and Yamada, H.: Report on flood disaster in Kinu River, occurred in September, 2015 (in Japanese with English abstract), Ecol. Civ. Eng., 19(2), 259–267, doi:10.3825/ece.19.259, 2017. Nedjati, A., Vizvari, B., Izbirak, G.: Post-earthquake response by small UAV helicopters, Nat. Hazards 80, 1669–1688, 2016. Doi: http://dx.doi.org/10.1007/ s11069-015-2046-6 Obanawa, H., Y. Hayakawa, and C. Gomez.: 3D Modelling of inaccessible Areas using UAV-based Aerial Photography and Structure from Motion. Transactions of the Japanese Geomorphological Union, 35, 283–294. 2014. Pham, T.-T.-H., P. Apparicio, C. Gomez, C. Weber, and D. Mathon.: Towards a rapid automatic detection of building damage using remote sensing for disaster management. The Haiti earthquake. Dis. Prev. Manage, 23, 53–66, 2014. doi: 10.1108/DPM-12-2012-0148 Pyo, J., Cho, H., Joe, H., Ura, T. and Yu, S.: Development of hovering type AUV " Cyclops " and its performance evaluation using

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RC - ii. The used acronyms are not consistent, RPAS, UAV, UAS, UVS were adopted at different places of the paper. If their definitions have major difference, the authors should define them clearly. If not, using one acronym for the whole paper may be considered.

AC - We revised the text, and we corrected these discrepancies.

RC - iii. Line 28-31, numbers within () should include unit, such as 380, 22765, etc. iv. Line 48, what is RLS and what are RTK/PPK at Line 95? The first time an acronym appear, its whole name should be explained. On the contrary, the explanation of GCP appear twice in the paper.

AC - We improve the text according to reviewer's suggestions. In particular: 380 are the average number of events per year (we add events in the text) 22,765 are fatalities (we add in the text) RLS should read SLR (single lens reflex) camera (we correct the text) RTK is Real Time Kinematic whereas PPK is Post Processing Kinematic (we add in the text)

RC - v. Table 1 specify the classification of Mini/Micro UAV. A reference should be referred.

AC - UVS International definition, added

RC - vi. Line 476, "small UAV" is used. What is its definition?

AC - fixed

RC - vii. Meanwhile, I doubt the definition in Table 1 is correct, as the Max. Flight altitude for Micro UAV is FIXED at 250m and its endurance time is also FIXED at 1h.

AC - Flight altitude depends on countries whereas endurance depends on the payload. Reported numbers are just indicative.

RC - viii. In this paper, the authors focus on the use of Mini and Micro RPAS only. However, these two kinds of RPAS are not suitable for volcano activities study, because its maximum flight altitude is generally lower than a volcano. For example at Line 422, a fixed-wing UAV can fly over Mt. Etna up to 4000m. This fixed-wing is not belong to the Mini or Micro RPAS. Right? There are other similar case studies that didn't use Mini or Micro RPAS as well.

AC - We thank the reviewer for this important issue. We added in the text that, for volcanoes, we also considered larger RPAS: Line 409: "As mentioned before, this paper considers in particular small RPAS. In the study of volcanoes, larger aircrafts with a payload of kilograms are also utilized to mount other types of sensors to monitor

various aspects of their dynamic activities. For this reason, in this chapter, we also consider larger RPAS solutions."

RC - ix. Line 212, RPAs or RPAS?.

AC - RPAS

RC - x. Line 415, two references for Gomez are not found in the list of reference.

AC - We added missing references, and we made a cross-check of all references mentioned in the manuscript and published in the reference list

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