Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2020-55-AC1, 2020

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "A semi-automatic procedure to support the detection of rapid-moving landslides using spaceborne SAR imagery" *by* Giuseppe Esposito et al.

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Received and published: 3 July 2020

General comments:

The paper entitled "A semi-automatic procedure to support the detection of rapid-moving landslides using space-borne SAR imagery" presents a semi-automatic procedure, exploiting Sentinel-1 SAR images, which evaluates changes of backscattering signals associated to land cover changes due to landsliding. The manuscript represents a solid and valuable contribution to the current state-of-the art landslide mapping and detection during in post-emergency phases. The scientific and the applied methods are excellently depicted and supported by a robust bibliographic background. The

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results are sound and consistent and supported by a very good statistical analysis, which makes the results very interesting and noteworthy. The discussion of the results in the general framework of the current literature is accurate and addresses all the concerns. The overall quality of the manuscript is very good, with an appropriate number of figures and written in an excellent English, to me. I have just a few questions which may be addressed in the discussion of the paper and which can be clarified by the authors.

Author response: We are grateful to the Reviewer for the valuable comments and suggestions relevant for the improvement of the manuscript. Point-by-point responses to all comments are outlined below. The proposed changes to the text and Figures are provided in the attached pdf file.

Specific comments

Title: The use of rapid landslide in the title can be ambiguous, since the definition of landslide magnitude can be obtained by assessing the intensity or the velocity. It is indeed a movement triggered by sudden events such as earthquakes, however, considering the current timespan between two S1 images. The same aspect should be clarified when using this expression throughout the text.

Author response: We agree with this comment. Both the title and some sentences in the text have been modified accordingly. In addition, this aspect has been explained into the Introduction section, by specifying that we focus on rapid-moving landslides since they determine more evident land cover changes with respect to slow-moving mass movements.

Dataset: I think that more information about the dataset used should be provided. A short reference within the text or by adding a table, along with the frame outline to be inserted in Figure 2, would be more appropriate.

Author response: Information on the dataset has been provided both into the sections

2.1 and 3. Further specifications have been inserted in section 3, as highlighted below:

“Considering that the majority of the slopes in the study area are exposed towards West, to limit geometrical distortions in the single images and in the change detection estimation, we preferred to use IW-SLC products acquired in ascending mode, with a VV-VH polarization. Each IW product is collected with a swath characterized by a width of 250 km, subdivided in turn to three sub-swaths containing one image per polarization consisting of a series of bursts which are processed as independent SLC images.”

A new version of Figure 2, including the spatial extent of the used Sentinel-1 SAR images, has been also prepared, as shown in the attached pdf file.

Speaking of the dataset, what about the geometry of acquisition? Did you use ascending or descending images? Moreover, do you expect differences in the final results by using both geometries? I also think a short comment on the potential geometric distortions of SAR imagery should be added in the text, if in somehow this may affect the goodness of the results.

Author response: In chapter 3 we have specified that this first application of the processing chain is based only on images acquired in ascending mode. This choice was taken a priori, taking into account that most of the slopes in the study area are exposed towards West, with the aim of limiting the inclusion of geometrical distortions. Besides this, we appreciate this valuable comment that gives us a starting point for improving the proposed procedure and considering the descending images in future steps. We agree that images acquired in both geometries can improve the quality of results, especially in mountainous areas. However, in this first application we focused mainly on the implementation of the processing chain, trying to get reasonable results in terms of output to a real case study. In the next steps, we will work to improve both detection and localization of landslide-related land cover changes, taking into account the possibility of combining ascending and descending images. We have added short comments in the Discussion section, as requested by the Reviewer.

Structure of the paper: I find ambiguous to write about the results when speaking of the test site. I find more appropriate to separate the result section from the paragraph 3, by adding a fourth paragraph which should address only the results obtained.

Author response: We structured the paper by describing firstly the implemented procedure, and subsequently the application in Papua New Guinea. The latter is described within the chapter 3 that is thus aimed at outlining the results obtained with the procedure described before. For this reason, we propose to do not change the structure of the paper.

Results: Do you think all the changes detected, even those within the ground truth landslides, can be attributed to landslides? Are there any other land cover changes that can be identified (e.g. deforestation, river deviation, noise, etc.)? You write, indeed (line 301), that many segments outside landslide areas are not attributable to landslides, however, it is possible to find these segments within the ground truth landslides? Do you think is sufficient to discriminate landslide and non-landslide pixels by their number?

Author response: Thanks for this comment that allows us to clarify this crucial point of the paper. It is possible to find segments related to noise and local stream changes also within the yellow polygons, where landslides occurred. However, segments related to these type of changes are relatively smaller than those ascribable to landslides, as shown in the unchanged zones represented in Figure 4(d). The occurrence of many and large landslide-related segments has strongly influenced the statistics of change detections 9 and 10 shown in Figure 5, with respect to the other change detections characterized mostly by noise-related smaller segments. Therefore, both the size and the number of segments resulted discriminant for landslides detection. We exclude changes related to earthquake damage into the yellow polygons, given that the study area is sparsely populated.

I think the classification of the detected segments is still a main challenge, which, of

course, could be addressed in future work. In this sense, do you think that a validation/comparison with other techniques and other data (e.g. PolSAR, OBIA, InSAR, DTM change detections) may help to better classify land cover changes segments?

Author response: We agree with the Reviewer. A future integration of different types of data and techniques may be useful to better classify the land cover changes and improve the landslides detection. Data at higher spatial and temporal resolution providing different types of information, for example, may allow validating and/or improving the current outcomes. However, it is worth noting that one of the strengths of our procedure is the use of data that are freely accessible, and with a constant revisiting time. This supported us in implementing an automatic processing chain.

Technical comments:

Line 96: please, specify that slightly better than 5 m by 5 m spatial resolution is when dealing with StripMap acquisition mode.

Author response: We agree with this comment. The sentence has been modified as follows:

"Satellites Sentinel-1A and 1B acquire images characterized by pixels with sizes ranging from 5 (range) $\times$ 20 (azimuth) m in the default acquisition mode for land observations (Interferometric Wide Swath mode - IW) up to 5x5 m, in the Strip Map mode".

Figure 2: as I said in a previous comment, SAR dataset frame could be added here to have a complete overview of the study area.

Author response: We agree with this comment and a new version of Figure 2, including the spatial coverage of the used Sentinel-1 SAR images, has been prepared. Please, see the attached pdf file.

Figure 4: please, add a color bar where necessary and the source of the optical image used.

Author response: We added a color bar only in the Figure 4(b), since it was missing in the early version. Further comments aimed to clarify the contents reported in the Figure 4(c), as well as the source of optical images used in the Figures 4(a) and 4(d) are added into the caption. Please, see the attached pdf file.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2020-55/nhess-2020-55-AC1-supplement.pdf

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