Responses to Reviewer #2

Donnini et al. present a framework for estimating landslide hazard. As I understand, the framework differs from an earlier one in so far that it considers higher-resolution landslide inventories. In the way the study is presented, I struggle seeing the novelty and it seems quite technical, mostly comparing results to this earlier method, while the broader relevance and importance is unclear. Please see my main comments below.

We thank Reviewer #2 for reviewing our article and for his helpful comments. As Reviewer #2 correctly writes, the framework for estimating landslide hazard presented in our MS builds on the method proposed by Cardinali et al. (2002), which we have acknowledged several times throughout the text, citing it as the "original method." However, differently from what the reviewer summarized, there are many differences that distinguish the framework proposed in our MS from the original method. The main differences are visually presented in Figure 3 and are: i) the analysis of three different inventories; ii) the comparison of the information content, materials, and methods used for the examined inventories with reference inventories; iii) a new method for estimating the frequency of all landslides (slow, fast, and rapid); iv) the use of the information derived from the ground motion time series as obtained through the persistent scatterers (PS) technique. These innovations certainly impact the final hazard assessment. Therefore, to visualize this impact, it is necessary to compare the results of the original and new methods. We acknowledge that this is a rather technical aspect of the MS, which we should nevertheless maintain with the aim of highlighting the improvement brought by our original results to the landslide hazard estimation. However, in the new version of the MS, we will strive to highlight the broader relevance and importance of our study, which currently seem partially hidden by the technical aspects.

What exactly is the novelty of the study? It seems like it’s an optimized version of earlier work. Many of the findings are compared to this earlier version of the method, but the broader relevance and implications are unclear. Findings like generational inventories (ie higher resolution) inventories provide more information is not surprising.

The response to the previous point also largely addresses this comment. However, differently to what the reviewer claims, our findings do not stress the unsurprising circumstance that higher resolution inventories provide more information for landslide hazard assessment. Actually, in a certain sense, it's quite the opposite. In fact, at line 767-772, the text read: "The comparison of different inventories indicates that the contribution of multi-temporal landslides (i.e. the landslides recognized after 1955) only enriches the information relating to the smaller and more scattered LHZs. Instead, multi-temporal landslides do not contribute to characterizing the landslide hazard of the study area, which instead is mostly controlled by previous landslides, already present in the generational-historical inventory, and only partially, in the basic-historical inventory." In other words: the multi-temporal inventory - which is the most detailed inventory we compiled - it is not decisive for the definition of the landslide hazard. Our findings rather substain that is important to base landslide hazard analysis on generational-historical inventories that adequately characterize the complexity of landslide clusters compared to the basic-historical inventories. This conclusion - independently confirmed by ground motion data - is not trivial and raises questions and research needs on the reliability and availability of landslide inventory maps used for landslide hazard studies and modelling.

As I understand, landslide inventories were generated, but the underlying mechanisms driving the hazard and leading to changes through time is hardly discussed. Understanding this would greatly help in assessing future hazards.

Our method base on the distribution and pattern of landslides contained in the available inventories, which allow one to infer the possible evolution of slopes, in terms of the most probable type of failures, and their expected frequency of occurrence and intensity. These are the conditions driving the landslide hazard of an area. The areas of evolution of these landslides are here named Landslide Hazard Zones (LHZs), and are defined as areas of possible (or probable) short-term evolution of existing landslides with similar characteristics (i.e. of type, volume, depth, and velocity). As specified in the ancillary materials, a LHZ is a "landslide scenario" delimited using geomorphological criteria considering (i) the partial or total reactivation of existing landslides, (ii) the lateral, head (retrogressive) or toe (progressive) expansion of the existing landslides, and (iii) the possible occurrence of new landslides of similar type and intensity. Within each LHZ, the levels of landslide hazard are expressed using an index that conveys, in a simple and compact format, information on the landslide frequency and the landslide intensity. Importantly, different LHZs with different levels of hazard can be determined for each type of failure observed on an elementary slope (e.g. fast-moving rock falls, rapid-moving debris flows, slow-moving earth-flow slumps or compound failures). This is very important because - according to our procedure - the overall hazard of an elementary slope is given by the combination of as many specific hazards as there are classes of typology and intensity of landslides recognized on that slope. This condition allowing us to keep track of the hazard posed also by pre-existing landslides which - although often partially hidden or remodeled - can represent the underlying mechanisms driving the hazard of most recent, and often active landslides. For instance, slow and pre-existing landslides partially or entirely overlain by fast and recent ones is a common geomorphological pattern in the study area, well captured by our generational-hystorical inventory. In such contexts, the continuous - albeit slow - movement of the underlying landslides generates and maintains the conditions of instability that promote the frequent activation of rock-fall within extensive rock fall areas. While we maintain that our results illustrate this complex chain of risks, we agree with the reviewer that this evidence is poorly discussed, remaining obscured by the technical aspects of the MS. In the new version of the manuscript, we will ensure a better balance between the discussion of the technical aspects and the scientific implications.

The Intorduction remains at a superficial level. Pros and cons of broad classes of methods (geomorphological, statistical, …) are listed, but with little detail and without identifiying the research gaps that are connected to this work. What is the motivation for the presented work?

The main scientific advances presented in the recent landslide hazard literature concerns physically-based analysis and statistical/ML approaches. Our study, however, presents a semi-quantitative heuristic approach, which, unlike modeling approaches, is little explored in the scientific literature, and this is a good motivation for the present work. The method we propose does not express landslide probability in modeling terms (probabilistic or deterministic), but defines landslide hazard areas based on landslides that have already occurred and the potential evolution zones for individual landslides or groups of landslides. Within these areas, it defines the hazard level based on the magnitude, velocity and frequency of landslides that have already occurred and are expected. While highlighting certain limitations, we maintain that our method represents an important advance in the field of semi-quantitative landslide hazard estimation because: i) it utilizes and optimizes information on landslide intensity and recurrence contained in inventory maps; ii) it takes into account the spatial and temporal dimensions of hazard; iii) it establishes a logical and reproducible procedure; iv) it overcomes the subjectivity of traditional geomorphological approaches; v) it provides maps directly applicable to land-use planning. In the new version of the MS, we will appropriately edit and strengthen the introduction by presenting and arguing for these improvements brought by our study, with respect to the research gaps and critical issues implicit in other heuristic approaches. In addition, as also stated to the other reviewer, the presentation of a new method for landslide hazard assessments is not the only result of this *work. Indeed, as the title suggests, the main objective of this paper is to demonstrate and measure the effect of different mapping approaches on landslide hazard estimation. In the new version of the manuscript, we will better highlight this additional result and its scientific relevance.*