

Referee 2

1) General comments (Anonymous Referee #2)

I would like to thank the authors for a highly interesting and original manuscript. I very much enjoyed reading it.

Authors' response: We deeply thank the referee for his/her encouragements and meaningful suggestions that will greatly help us to improve the paper. In what follows, we provide a point-by-point answer to his/her comments, questions and suggestions.

2) Comments

Page 2: "A specific concern is related to complex and/or cascading hazards that can have far-reaching and multiple consequences downstream" -> I think it would be good to provide a very clear definition of multi, consecutive, cascading, etc risk. Similarly, a couple of sentences down (risks related to natural hazards are broadly defined here as the results of interactions between natural and societal components), I wonder if it would be good to explicitly define is as exposure and vulnerability (and risk) very clearly? And eg in L. 329 you talk about "cascading multi-hazards".

Authors' response: A multitude of terms has been proposed to account for increasingly complex hazards and risks, e.g. multi-hazards, cascading hazards, domino effects, compound events, cascading risks, interconnected risks, etc. (e.g. Simpson *et al.*, 2021; Zscheischler *et al.*, 2018). Despite the slight difference in meaning between these different terms, they all emphasize the importance of interactions between hazards and/or exposed elements. In the paper, we use the multirisk concept in a broad sense, namely all single risks and their interactions at the territorial scale, with interactions concerning potentially hazards and/or impacts. Similarly, we define multi-hazards as all single hazards and their interactions at the territorial scale. Interactions that sources identified correspond all to cascading hazards, namely the 12 pairs of successive hazards for which causal linkages were reported. Potentially other types of interactions between hazards may have existed, but the information was not available. In the reworked version of the paper, we will make an extra-effort to clarify these definitions.

Regarding our risk definition, it was similarly chosen to be broad enough to easily account for elements that are not directly explicit in the classical IPCC risk decomposition between hazard, vulnerability and exposure, such as spatio-temporal dynamics, delayed interactions etc. Again, the reworked version of the paper will make this even more explicit.

The authors speak of a multirisk database that covers centuries, but it covers hazards and impact, right? It would be good to clarify this; I also found section 3.4.1 a bit unclear.

Authors' response: Our formulation was indeed a bit awkward. In the revised version of the paper we will reformulate the sentence as: "The multirisk database gathers a range of information to characterize various hazards and their impacts over a pluricentennial time frame: hydrological hazards, rockfalls, avalanches, landslides and glacial hazards". We will also rework the whole paragraph to make it clearer.

Out of curiosity: have definitions of individual hazard types changed over time (eg land movement or rockfall)?

Authors' response: We chose a primary broad hazard categorisation (avalanches, landslides, etc.) to be able to classify the events from the sources without any subjective choice. These denominations could be found in sources more or less independently of time. However, the sources often provide a more specific description and typology of hazards that did actually change over time and makes it difficult to define homogeneous sub-categories all over the study period. Notably whereas sub-categories are nowadays rather homogenous and normalized between sources, they were much more variable from source to another earlier on. See also our response to referee 1 about the emergence of the debris flow concept during the nineteenth century. Another example is that until the beginning of the 20th century powder snow avalanches were sometimes denoted "dust avalanches". In the revised version of the paper we will better justify our broad hazard categorization and discuss the changes in sub-typologies provided by sources as function of time.

4.2: by event, do you mean disaster? (so when a hazard interacts with exposure and vulnerability of that exposure)? In the next section you talk about impacted assets, but does this mean that you exclude vulnerability?

Authors' response: As stated in the paper, following Giacona et al. (2021) 'event' means the occurrence of a given hazard and its characteristics, including impacts retrieved from sources. This broad definition means that an event is not necessarily a disaster, since sources also sometimes report hazards that did not cause damage. With the aim of having the records as comprehensive as possible, we also keep such events. However, it is true that events that caused damage are over-represented in the database, especially in the early period of the record. This is common in hazard records resulting from historical sources as disasters are generally more systematically recorded and better preserved by sources than events that did not impact societies (Giacona et al., 2017).

Regarding impacts, we made specific efforts to document all the different types of impacts the events caused, including physical damage to people, buildings, infrastructures and forests, but also, e.g. accessibility losses (road closures) and disruption of various networks such as electric lines. This all in turn informs regarding local vulnerability and how it evolved through time (See also our response about the hazard/vulnerability/exposition of risk). However, certain types of vulnerabilities such as the broad social and organizational vulnerability of the Vallouise-Pelvoux community is barely reflected in our damage record. More broadly, our work is not a comprehensive study of the local vulnerability (as it is not a comprehensive study of the local risk system or of local hazard activity). This could be the goal of further work, for which the information summed up will be a good starting point, to be combined with other information. In the revised version of the paper we will expand the outlook section to include this perspective.

Looking at the analysis in section 4.5, I wondered why we see such a peak in number of disasters around 1950-1970?

Authors' response: As stated in the paper the database context and especially the shape of event chronologies results in a complex combination of sources, exposure and wider social practices and process activity. Understanding the shape in the chronologies involves an in-depth analysis to distangle the different effects, which is beyond the analysis carried so far (but is a priority for future work). At this stage we therefore do not have a clear explanation for this 1950-1970 peak, except that arguably since the mid 20th century we probably have a much more comprehensive record as for earlier periods, which combines with numerous new elements at risk related to tourism development. The recent decrease could be linked to better protection measures for this new elements at risk combined to anthropogenic warming. But again this explanation is rather speculative at this stage. IN the revised version of the paper, we will indicate that the 1950-1970 peak is an excellent example of a pattern that an in-depth analysis of event and context data could explain, to determine if it is related to changes in sources, exposure and/or process activity.

I would be curious to read a bit more of an in depth/critical reflection on and discussion of the notion of single vs (cascading?) multi-risk and the recording (and hence perception) thereof.

Authors' response: First, as already stated the database was built with the objective to avoid any subjectivity, restricting strictly the information recorded to what the sources actually say. Regarding multi-hazards, this resulted in 12 cascading hazards "only" (see our response above regarding definitions). Potentially other types of interactions between hazards may have existed, or other pairs of hazards may have succeed, but the information was not available. Second, within our multirisk approach, interactions between damage are also considered, and as soon as they have been mentioned in the sources they have been carefully kept, e.g. damage to critical infrastructure that caused various types of economic losses. These cascading consequences are not analyzed in the paper which is already long. See our response to Joel Guil about perception of multi-hazards. The same more or less applies to cascading impacts, e.g. it is likely that their proportion (and arguably diversity) is underestimated in the database as the whole information could

certainly not be extracted from the sources, especially for the old times. An interesting further work would therefore be to i) try to expand the documentation of cascading hazards/impacts from additional resources, expand the analysis of the most complex events of the database (e.g. those with cascading impacts), iii) try to get the picture as complete as possible of multirisk patterns and their change in the study area, taking into account changes in the ways interactions between hazards and/or damage were perceived or not. Of course this is something very ambitious that will require lots of additional research. In the reworked version of the paper, we will include some discussion elements on this purpose.

3) Minor comments

7 L. 190: studied period -> should be study period

Authors' response: We will make the correction in the revised version of the paper: "The variety of pre-existing and new sources mobilized in the constitution of the database allowed us to cover the 420-year study period"

275: "mobilized sources" -> do you mean used sources?

Authors' response: We will make the correction in the revised version of the paper: "This first set of pre-existing sources used (sect. 3.2), although substantial, presents weaknesses."

293: "torrents" -> do the authors mean torrential rainfall?

Authors' response: no it means torrents as river, generally of moderate size, and with a slope greater than 6%, with specific flood regimes (often highly charged in sediment". We will add a note in the revised version of the manuscript.

You write multirisk and multi-hazard, I would hyphenate both.

Authors' response: Right. For consistency we will use "multirisk" and "multihazard" in the revised version of the paper, with clear definitions at the first occurrence of the term.

636: I am not sure I would call the frequency figures a statistical analysis.

Authors' response: True, our formulation was a bit "too much" also it was referring not only to the chronologies of events. We will reformulate as: "Indeed, the first analyses (distribution of events according to sources, space, time, damage etc.) already highlight the potential of the information for more in-depth studies."

References:

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