Author comment to anonymous Referee 1

Dear Editor and Reviewer 1,

We thank the reviewer for the careful and in-depth analysis of our manuscript. We appreciate the recognition of our work as a valuable empirical contribution and your thoughtful suggestions to strengthen its analytical structure, terminological clarity, and methodological positioning.

We have carefully revised the manuscript in light of your comments. Below, we provide a detailed, point-by-point response.

General comments

We appreciate the reviewer's insightful observations, which help clarify the scope and intent of this work. This manuscript should be understood as the very first link in a longer chain of studies that will address the full cycle of multi-hazard data management: compilation, structuring, organization, standardization, processing, analysis, and application. In this initial stage—already representing a substantial effort in terms of research and data gathering—our priority has been to document all hazard-related events exactly as they appear in the historical and bibliographic sources, without reinterpreting or reclassifying them according to existing international frameworks or typologies. This choice was deliberate: applying a classification at this stage would inevitably introduce a degree of subjectivity, which we aim to avoid by designing an automated, data-driven standardization process in later phases.

Our long-term goal is to implement advanced data science techniques—such as machine learning and artificial intelligence—to derive hazard classifications, identify interdependencies, and establish objective, reproducible categories directly from the data itself. While we are fully aware that the current dataset is not yet standardized, interoperable, or ready for direct integration into modelling tools, this step is crucial to ensure that future versions are built on a robust, unbiased foundation. By proceeding in this way, we avoid the risk of producing yet another static database constrained by pre-set typologies, and instead lay the groundwork for a flexible, evidence-based resource that can be adapted to evolving risk governance and technological contexts.

Section 2: Geological context and natural hazards

We thank the reviewer for this observation. We respectfully acknowledge the relevance of other eruptions in the Canary Islands and, especially, the 2021 Tajogaite eruption in La Palma as a recent and high-impact event in the region. However, we would like to clarify the rationale behind the structure and scope of Section 2.

This section is intentionally designed to transition from a broad-scale (archipelagic) overview to a focused discussion of Tenerife, the study area of the paper and the sole island covered by the dataset. While we agree that La Palma's eruption is notable, including it without also referencing the 13 other historical eruptions in the Canary Islands would introduce a selective bias. Moreover, assessing whether Tajogaite was the "most damaging" eruption in Canary Islands history is debatable. Such a claim would require a standardized evaluation of direct and indirect losses (economic, social, environmental), adjusted over time for inflation, population, and development levels—metrics that are not comprehensively available for all historical eruptions. The eruption of Lanzarote in 1730-1736, for example, with almost two cubic kilometers of magma emitted, was much worse and forced the almost total evacuation of the island. For this reason, and to preserve historical consistency and avoid overemphasizing recent events, we have not included it in this section.

According to that, we think it is necessary to focus on our case study, since each island has its own particularities, and although we can give a more general introduction, we don't think it would be necessary to detail other events on the other islands, because then we would also have to talk about floods, landslides, seismicity, not just eruptions. That said, in response to the reviewer’s suggestion and to provide additional context, we have added one sentence referencing the regional volcanic hazard across the archipelago and acknowledging that recent eruptions, such as that of Tajogaite (2021), underscore the ongoing relevance of volcanic risk. This maintains the Tenerife-centric scope of the manuscript while acknowledging broader processes.

On the other hand, we agree with the reviewer that the section could better highlight interactions among natural hazards (geological, hydrological, and weather-related hazards), especially those common in Tenerife (e.g., seismicity triggering landslides, eruptions following increased seismic swarms). However, we believe such patterns should emerge from systematic analysis of the dataset, rather than being pre-emptively inferred from anecdotal or visual inspection. As such, we have deliberately avoided subjective interpretation of event relationships unless they are explicitly documented in historical records.

In the revised manuscript, we have added a brief paragraph at the end of the (now) geographical, geological and climatic context section indicating that several types of interactions were captured in the dataset—particularly seismic-volcanic and rainfall-landslide interactions—and that future work will explore these using quantitative methods such as event trees and network analysis.

Regarding the recent seismic uptick, we have chosen not to emphasize this further. The database spans over 500 years, during which numerous similar episodes of seismic unrest have occurred. Highlighting the most recent instance could unintentionally bias the temporal neutrality of the analysis, especially when such episodes have not (yet) resulted in eruptions or documented impacts. Instead, we now reiterate in the conclusion that the dataset is designed to be periodically updated, and future additions will incorporate both newly documented events and new types of analysis, including temporal clustering.

As you suggested, we have renamed and restructured Section 2 as “Geographical, geological and climatic context” of Tenerife, integrating both physical and meteorological elements, to avoid the impression that the study’s context is exclusively volcanic or geological. This change improves the internal coherence of the manuscript and addresses the reviewer’s concern about focus.

Section 3. Natural hazards, risk management and risk regulation

We thank the reviewer for this observation and acknowledge that in the current version, the purpose of introducing the PEIN (2020) risk classification may not be sufficiently clear. The intention was not to replicate PEIN's methodology as part of our analysis, but rather to set the institutional context:

- to show how hazards are formally prioritized in the official risk management framework of Tenerife, and
- to illustrate which hazards are currently of greatest concern to the local government.

We agree that the link to our own work needs to be made explicit. The PEIN (2020) identifies a broad spectrum of natural hazards for Tenerife, including volcanic eruptions, floods, ruptures of storage infrastructures, earthquakes, tsunamis, snowfall, torrential rains, hailstorms, frost, strong winds, coastal storms, heatwaves, haze/dust, droughts, rockfalls, landslides, and coastal erosion.

For the purpose of this study, the dataset focuses on five hazard types:

- Volcanic eruptions
- Earthquakes
- Tsunamis
- Landslides and rockfalls
- Floods

This narrower selection is based on three criteria:

1. Documented historical occurrence (1494–2020) – Only hazards with recurrent, well-documented events over at least several centuries were included, ensuring consistency and reliability in long-term analysis.
2. Availability and quality of historical records – Hazards such as hailstorms, heatwaves, or droughts are relevant but lack sufficiently detailed and consistent historical documentation to support robust analysis in this version of the dataset.
3. Cascading and multi-hazard potential – Selected hazards are known to trigger or be triggered by other events, making them particularly relevant for multi-hazard analysis.
4. These hazards are the ones covered by special plans designed to manage this type of hazard and any resulting emergencies.

This justification has been included in the Methodology section. We emphasize that this is not a judgement on the relative importance of excluded hazards for present-day or future risk management. On the contrary, we recognize that some hazards not included here may gain prominence under climate change scenarios. Our scope is determined by the nature and completeness of available historical data, not by an institutional priority ranking.

Future iterations of the dataset could integrate additional hazards from the PEIN list as historical records are expanded, digitized, or supplemented with palaeoenvironmental or instrumental datasets.

On the other hand, we agree with the reviewer that the analytical flow can be improved by restructuring this section. In the revised manuscript:

1. The climatic context of Tenerife (current weather regimes, precipitation patterns, and hydrometeorological drivers) has been moved from Section 3 to Section 2, which now provides a comprehensive geographical, climatic, and geological context for the island. This allows readers to first understand present-day climatic conditions before considering hazard patterns.
2. The PEIN risk classification remains in Section 3, but the section has been reframed to focus on how hazards are officially recognized, categorized, and prioritized by the Cabildo de Tenerife. We now provide a clearer explanation of the institutional role of the Cabildo as the insular authority responsible for risk management, and how the PEIN integrates into the broader Canary Islands and national DRR governance architecture. We also note that the current planning framework is predominantly single-hazard and does not yet incorporate an integrated multi-hazard approach—reinforcing the relevance of our historical dataset.

This restructuring clarifies the purpose of each component:

- Section 2 – the physical and climatic setting that explains hazard occurrence.
- Section 3 – the institutional hazard inventory and prioritization that forms the starting point for our historical hazard analysis.

Finally, we agree that briefly outlining the broader governance structure can strengthen the contextual foundation of the paper and reinforce the dataset's relevance. While an in-depth governance analysis is beyond the scope of this manuscript, we have now included a short paragraph summarizing how natural hazard risk management is organized in the Canary Islands, the role of the PEIN within this system, and the predominance of single-hazard planning approaches. In addition, reasoning has been added to the justification section that links the information that can be extracted from the PEIN with the results of our analysis of the dataset.

This addition clarifies that our historical multi-hazard dataset provides a foundational evidence base to support future integrated multi-hazard strategies. It also makes explicit why we begin Section 3 with the PEIN hazard list and classification: to anchor our analysis in the current institutional perception and management of risk.

Section 4. Methodology

We thank the reviewer for pointing out the inconsistency in hazard classification. This was inherited from the way some special emergency plans in the Canary Islands are presented, where certain hazards are grouped under "geological" plans despite being of hydrological or meteorological origin. Since these plans informed part of our hazard selection, the classification was initially transcribed without modification. The manuscript has now been corrected to distinguish between *geological* hazards (e.g., volcanic eruptions, earthquakes, landslides, rock falls) and *hydrological* hazards (e.g., floods), in line with the PEIN and international usage. The term “hydrological” has been preferred over “hydrometeorological” to account for other types of triggering events such as tsunamis or dam failures.

Regarding the integration of existing multi-hazard frameworks, we agree that distinctions such as primary/secondary hazards, triggering relationships, and cascading or compound events are essential for multi-hazard risk analysis. However, this dataset was intentionally designed as a first, objective, data-gathering step, recording all identified events in the historical record of Tenerife without interpretive classification of interrelationships. This ensures that the dataset captures the full spectrum of events—regardless of whether their connections are already known or remain to be discovered—avoiding bias in the initial compilation phase. Some cascading events have been labelled as such only when explicitly identified in the source literature, but in most cases, relational patterns will be established through subsequent analysis.

We have revised the text to:

1. Clarify the rationale for this approach;
2. Explicitly situate our methodology as the foundation for later alignment with established hazard typologies and frameworks (e.g., UNDRR, Gill & Malamud 2016, Kappes et al. 2012, López-Saavedra & Martí 2023);
3. Highlight that interoperability with other datasets is a planned next step once analytical processing of these historical records is complete.

Section 5. Results

We appreciate the reviewer's comments, and the inconsistencies in the figure numbers have been corrected, as well as some of the references mentioned have been added.

The generation of other figures, such as temporal evolution and spatial distribution, although very useful, are reserved for later processing and analysis, as mentioned above. An approximation has been made in the discussion, but they are outside the scope of the paper, so we have limited ourselves to a preliminary description of the dataset without going into detail, as it is also necessary to first look at cause-effect relationships, patterns, and interrelationships, among other things.

The words “risk” and “hazard” have been reviewed and some corrected, but we confirm that they have been used consciously in accordance with what was intended to be expressed according to their meaning: hazard for the phenomenon, and risk for its potential damage or damaged caused.

Regarding the consequences of landslides and rock falls mentioned in line 320, the reviewer is correct and we agree that a death should entail a cost, if not economic, then certainly a much greater social one, however we have limited ourselves to describing what has been compiled from the written press. In the case of landslides in ravines and on beaches, compared to other events such as eruptions, in many cases there have been no large-scale evacuations or preventive evacuations prior to the danger. Perhaps temporary closure of the area and this is already included in the dataset, which should always be considered as the source of information, not just the main text. Even so, perhaps we did not see at the time the sensitivity that the reviewer mentions, and for that reason, we wanted to add a clarification in the text so that there are no misunderstandings.

As for the types of interrelationships, as mentioned above, this will be left until the data processing is carried out and the exact types of patterns in the dataset are known. In the case of the sentence indicated by the reviewer on line 317, the sentence has been adapted in the hope that it will now be better understood, but what is meant is that the landslides or rockfalls recorded in the dataset have not triggered other events in a cascade effect, as is clearly recorded in the literature consulted for other hazards.

In the case of the relationship between floods and weather patterns, it is true that this is not mentioned above, but for the same reason we mentioned earlier: to avoid establishing relationships that have not emerged from the observation and processing of the dataset, so as not to reach conclusions based on subjectivity. In section 2, when discussing tropical storms and Atlantic squalls, the type of phenomena they produce, such as unstable weather and precipitation, is already mentioned, and then in the results section, a coincidence of floods with the seasons when such unstable weather occurs is described, hence the relationship.

Regarding the comment on line 332, a sentence has already been added to clarify this reference to "preceding events."

Section 6. Discussion

We appreciate the reviewer's suggestion to further connect the recommendations with multi-hazard contexts and to consider potential synergies or trade-offs. While the primary aim of this study was to develop and present the historical multi-hazard dataset, rather than to conduct a full policy analysis, we agree that briefly acknowledging how some measures may interact with other hazards can enhance the discussion. We have therefore added a short paragraph noting these interrelations, and referencing examples from the literature where similar measures have been applied in comparable insular or volcanic regions. This addition preserves the descriptive nature of our work while strengthening the linkage between the dataset findings, the proposed measures, and broader DRR strategies.

Errors in references to figures have been corrected. Additional bibliographic references have also been added to support some statements, but this point has not been expanded upon much further, as these recommendations are based on experience or expert opinion and it has already been made clear in the corrected text that they require analysis of their applicability before being implemented.

Given that the dataset focuses exclusively on volcanic eruptions, earthquakes, floods, landslides/rockfalls, and tsunamis, we cannot expand further on other hazards because, on the one hand, we do not have and have not collected sufficient data to analyze them objectively and treat them appropriately without relying on our own experience and knowledge of the region and, on the other hand, because it exceeds the scope of the article and would make it too long. For this reason, they have been mentioned briefly so as not to overlook them, and its potential to amplify or cause other hazards has already been highlighted in the text, but they couldn't more thoroughly analyzed

On the other hand, we acknowledge the reviewer's comment and agree that clarifying the current limitations of the dataset will strengthen the manuscript. While the dataset is already structured to allow for future applications in risk modelling and machine learning, its present form should be understood as a first version, focused on compilation and harmonisation of historical data in order to standardize it in next steps. Explicitly recognising the current gaps in metadata standardization, indicators, and validation protocols will help set realistic expectations and guide future improvements, for that reason we have included a paragraph at the end of the conclusion section.

As for vulnerability and socioeconomic dynamics, this will come much later. This document should be understood as the first piece in a whole chain that will cover the entire process, so addressing it here without being rigorous with the methodology could lead to results or treatment of this information that, as is often the case, would be subject to subjectivity or would simply remain as recommendations, something we do not want. Nevertheless, we appreciate this contribution, as we consider it very valuable and it reinforces our intention to continue with this work.

Once again, we thank the reviewer for her insightful and encouraging review. We believe these changes significantly improve the manuscript's clarity, completeness, and utility, and we hope it now meets the high standards expected by the journal.

With kind regards,

Marta López-Saavedra
Corresponding author on behalf of all co-authors
August 2025