

Authors response (in green) to referee and editor comments (in black)

Anonymous referee #2:

This study contributes to disaster risk science by developing an algorithm to identify multi-hazard events using information on associated hazards and spatiotemporal relationships in EM-DAT records. It suggests creating generic archetypes of multi-hazard risk dynamics to enhance risk analysis and decision-making. While acknowledging EM-DAT's limitations, the study highlights the database's value in identifying global multi-hazard impact patterns and recommends improvements in data reporting.

The authors have successfully addressed all concerns raised during the first review, resulting in a manuscript that significantly improves in readability and flow. I recommend the following minor corrections before publication:

We thank the reviewer for taking the time to carefully review the article again.

- L190: The sentence appears unfinished: “disaster types listed in the second column of...” Added “Table 2.”
- L200: The sentence appears unfinished: “We use the same terms for the hazard types as (Claassen et al., 2023); they are given in the first column of...” Changed to “as Claassen et al. (2023)
- L395: Add “an” to the sentence: “The aim of this study was to gain (an) understanding of multi-hazards and their compounding impacts by analysing the emergency events database EM-DAT.” Done.
- L488: Change “than” to “as”: “In all archetypes, hazard pairs tend to have at least as much impact than (as) single hazards or combinations of two single hazards, but never less impact.” Done.
- L494: Separate this long sentence into multiple shorter sentences for improved clarity and grammar. For example: “For some types of hazards and impacts, modeling the impact of one dominant hazard may yield a reasonable approximation of multi-hazard impact. In other cases, modeling single hazard impacts separately and adding them up may also provide a reasonable approximation. However, it may be important to consider interaction effects that could lead to either increased or decreased impacts compared to a simple sum of individual impacts.” We followed the suggestion closely and broke up the long sentence into these three shorter ones: “For some types of hazard and impact, modelling the impact of a dominant hazard may yield a reasonable approximation of the total multi-hazard impact. In other cases, modelling single-hazard impacts separately and summing them may be sufficient. However, in other situations, considering interaction effects is crucial, as they can either increase or decrease the total impact compared to a simple sum of individual impacts.”

- L507: Change the sentence to: “In the short term, we recommend improving and supporting the existing information in EM-DAT.” Done.

Editor:

There are a few comments/suggestions I would like to make: We thank the editor for below suggestions to help make the manuscript more clear to readers.

- L.13 p.1: “Overall”. I think these values correspond to the 50% spatial and 90 days temporal match. It is not very clear with the current wording. We adjusted to: “We find that 35% of events are multi-hazard events, and 61% of hazards are associated with them, based on a spatial overlap of at least 50% and a time lag of at most three months. The hazards associated with multi-hazard events account for 78% of total damages, 83% of total people affected, and 69% of total deaths.”

- L.142 p.5: “when data are not missing at random”. I think there is a word missing at the end of the sentence, “locations” maybe? “Missing not at random” is a statistical term and “Data is missing not at random” would be a full sentence. We added the following footnote and reference to explain this term and avoid confusion: “Missing not at random” is a statistical term referring to the likelihood of data being missing being dependent on characteristics of the disaster event (Rubin, 1976), for example, geographic location or disaster type.

- L.279 p.11: “We create the dataset by selecting all events (including the duplicates) consisting of one or two hazards”. So what happens to events with more than two hazards? Are they discarded? If, yes, how many events are removed? We added the following paragraph to provide more detail on this: “If an event consists of more than two hazards, we exclude it from this part of the analysis. Such events are either partial duplicates – where the first one or two hazards are already represented by another event – or they correspond to a disaster record with three hazards. For example, we exclude the event “A1, C1, C2, C3”. While “A1” is included as single hazard, we cannot include “A1, C1” as a hazard pair because EM-DAT only reports the joint impact of “C1, C2, C3” rather than the individual impacts of “C1”, “C2” and “C3” separately. As a result, the disaster record “C1, C2, C3” is not included in the analysis. In total, we had to exclude 1079 (18%) of the EM-DAT disaster records from this part of the analysis due to the aggregated reporting of impacts for all hazards within a record.”

- Figure 4 p.15: Please improve the quality of the figure (resolutions). I would also suggest putting all loss metrics on a logarithmic scale to improve readability.

We have increased the resolution of the figure and added a logarithmic scale to one of the plots (number of deaths for extreme winds and floods -panel in the second row, first column). For this case, readability improves indeed. However for the other plots, the readability for the boxplots improves while the readability for the confidence intervals

decreases. As we mainly compare the confidence intervals, we have decided to keep the linear scale for all other plots.

While revisiting this figure we noticed that the plot for number of deaths for floods and landslides was accidentally greyed out (missing), although it was being described in the text. We have added this plot.

We also noticed two typo's in table 3: '=' signs which should have been a '<' signs. We corrected these as well as the corresponding sentence parts in the results (l.401), discussion (l. 447), conclusions (l.515) and abstract (l.21).

Finally, we have changed a few more typo's.