Response to Reviewer 2

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January 22, 2024

General Comment: This is an ambitious paper simulating multi-hazard event sets for life cycle consequence analysis. The methodology is transparent and is systematically presented, and should meet the general requirements of life cycle consequence analysis. However, it should be made clear that uncommon combinations of different hazards can create dangerous hazard situations. With progressive climate change, these dangerous hazard situations may arise more often. Thus the occurrence of a typhoon close to an earthquake can have a major impact on fire and landslide risk, as demonstrated in Japan in September 1923 in Tokyo, and September 2018 in Hokkaido.

Some systems may demand a very high degree of life cycle reliability. The authors should stress test their Poisson process modelling to gauge the sensitivity of the model results to anomalous rare compound event behaviour. End users should not be surprised by such phenomena.

We thank the reviewer for the attentive reading of the manuscript, and we hereby gratefully acknowledge the positive remarks. Indeed, the formulation presented in this paper can capture (and quantify the probability of) the occurrence of rare combinations of events that arise from sheer temporal coincidence rather than causality (i.e., interactions). Employing competing Poisson processes in the formulation offers a distinct advantage in accommodating both types of phenomena. This allows the model not only to identify commonly considered sequences of dependent events, such as mainshocks and aftershocks or heavy rain and flooding but also to enumerate 'coincidental' combinations of hazards. For instance, scenarios like a typhoon occurring in close (temporal and spatial) proximity to an earthquake, as highlighted by the reviewer, can be systematically incorporated into the analysis. We will modify and add several sentences in the manuscript to stress this aspect.

We plan to add the following discussion on Line 20 (Page 1):

> In fact, the occurrence of multiple events within a short time span (whether dictated by a causality between events or by sheer coincidence) may subject the system to exacerbated economic and societal consequences (de Ruiter et al., 2020). Such consequences have been increasing over the past decades (Di Baldassarre et al., 2018) due to several factors such as climate change, urbanization, and globalization (Cutter et al., 2008; Cutter, 2018).

We plan to add the following discussion on Line 417 (Page 20):

> This sort of 'coincidental' hazard combinations should not surprise end users of the algorithm. In fact, such combinations have been observed on multiple occasions over the past century and are expected to increase due to climate change (Cutter et al., 2008). For example, typhoons were recorded in close temporal proximity to the great Kanto earthquake (Japan) of 1923 (Sasaki and Yamakawa, 2007) and the Hokkaido earthquake (Japan) of 2018 (Heidarzadeh et al., 2023). Although less frequent, these combinations are just as crucial as those influenced by causality (de Ruiter et al., 2020). An additional advantage of the proposed method is that it seamlessly integrates causal and coincidental event combinations within the same formulation.

We plan to add the following discussion on Line 436 (Page 22):

> By using competing Poisson processes and integrating both dependent and independent hazards within the same methodology, the proposed simulation approach offers insights into the combination of hazards arising from causality (i.e., hazard interactions) and those emerging from sheer temporal coincidence. The significance of these hazard combinations, especially in the context of their anticipated growth due to climate change effects in the coming years, should not be underestimated. By allowing the modification of the rate curves used as input to the model, the proposed algorithm enables incorporating such climate change aspects.

We believe that the numerical example provided in the manuscript already showcases the method's potential to capture the presence of rare, coincidental hazard combinations.

For example, Lines 413-417 on Page 21 read:

> It can be observed that even hazard types that are not related by level I interactions may occur close (in time) to each other. For example, there are, on average 2.62 main shock events following the occurrence of a heavy rain event and 1.47 heavy rain events following a mainshock event, which might suggest that the interactions between such (independent) hazards might be of interest in a possible life cycle analysis of a structure placed in the investigated location.

As for the consequences of such rare hazard combinations, their investigation is deferred to works on Level II interactions, which are not the focus of this paper, but are explored in other works by the authors such as Otárola et al. (2023a,b) .

General Comment 2: The authors should address

We interpreted this sentence as a typo in the review, and we have no further comments. In case the review was somehow submitted incompletely, we will be happy to address any of the reviewer's additional comments.

References

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