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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Damage functions for climate-related hazards: unification and uncertainty analysis" *by* B. F. Prahl et al.

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We would like to thank the reviewer for his comments leading to further improvement of our manuscript. Our response to the individual comments are given in blue below.

General comments

The paper presents a formulation of a unified damage function on intermediate complexity. Based on explicit or implicit treatment of individual items within a given portfolio, a generalized damage function is formulated to describe relative damages to such portfolio. Exemplary case studies are presented including a sensitivity analysis of different uncertainty sources.

The presented framework offers a simple and universal methodology which is, in theory, applicable to a number of scenarios and thus poses a significant step towards a unification of damage functions.

In general however, I find reading the manuscript a bit confusing, which certainly is partly due to its structure. In my opinion, readability of the document is affected by dividing the content of the manuscript into main text, appendices and supplementary material. Many details and explanations necessary to understand the fundamental ideas of this paper as well as the discussed example cases are missing when reading the main text.

The structure of the manuscript was supposed to make the manuscript more accessible and easier to follow. Clearly, as all reviewers have stated, we failed to achieve this goal. Therefore we will thoroughly revise and simplify the structure of the manuscript.

One weakness of the manuscript in my opinion is the fact, that it does not give evidence to the question, why the formulated damage function can be (a) assumed universal in a practical sense as stated by the authors and (b) why this framework offers further insight compared to the cited approaches for the individual damage modelling approaches. Even though the discussion of different case studies demonstrates the technical applicability of the unified damage function, from reading manuscript the benefits remain unclear and remain somehow speculative.

We did not intend to claim that the proposed damage function is universal. That said, we do see wide applicability to different hazards. We further believe it worthwhile to explore the analogies of the application to different hazards. We go beyond the cited works by systematically including uncertainties into the damage function. Based on this extension, we took a novel approach to sensitivity analysis, by focussing on the behaviour at different hazard magnitude and assessment scales. Our work puts strong emphasis on the mechanics of damage functions – an aspect that is often sidelined in

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damage assessment. Furthermore, our results have advanced the understanding of uncertainty and may guide practitioners in considering relevant uncertainties.
In the revised manuscript, we will make clear the novelty of our contributions and further discuss their benefits.

Specific comments

6850: Lines 11-16: Particularly for severe events, damages might be highly sensitive to macroscopic effects such as crevasse. In the proposed framework, such effects pose immediate effect on a (large) share of the individual hazard thresholds within the portfolio. It should thus be discussed in how far this influences the uncertainties within the proposed methodology.

We thank the reviewer for raising this interesting issue. It has been aknowledged in the literature that crevasses pose a substantial source of uncertainty. We will comment on this in the revised manuscript.

6855, Lines 24-26.: It should be explained why the authors consider the discussed sources of uncertainties as the major ones. Otherwise this remains an assumption only.

The discussed uncertainties consider all potential inputs to the damage function. Uncertainties related to wrong model choice or from parameter estimation are not considered.

6856, Lines 1-11.: To be able to understand and interpret the results, details on the set up of the case studies are missing (even in the supplementary material). E.g. information and sources of predictor variables and damage data should be specified.

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The intention of this comment is unclear to us. In case of Lisbon, the damage function is synthetic and requires neither predictor nor loss data. For the storm case, we will add some information on the data that has been used by the cited authors.

6857, Lines 1-7: It does not become clear, how the Monte Carlo methodology is performed nor how it is linked to the given details in the supplementary material.

There have also been a series of comments by the first reviewer regarding this section. We understand that our description has been too brief and will rewrite the entire section for clarity.

6858: Lines 1-5: Figure 2e not only shows a strong increase in affected buildings at thresholds exceeding 4 m, but also at higher thresholds rather steep increases arise. It should be discussed why these "jumps" do not lead to similar effects on the threshold uncertainty on the macroscopic level.

In Fig. 5b we see a marked bump after 4m and lesser bumps after 6m and just before 8m. These are in fact the outcomes of the jumps in affected buildings seen in Fig. 2e. The later bumps are much less pronounced, as there are more and more buildings affected and so the fraction (and the effect) of newly affected buildings becomes smaller in relation. We make this more clear in the revised manuscript.

6858, Lines 11-15: I do not see how the low increase of affected buildings lead to higher impacts of intrinsic uncertainties. Clarification on that should be given possibly including interpretation of this aspect.

There are two processes at work here. Firstly, as more and more buildings are affected, the aggregated variance of intrinsic uncertainties grows at a lower rate than extrinsic uncertainty. Secondly, intrinsic uncertainty grows with the average damage.

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In combination, a low increase means that the second effect dominates over the first, while at high growth rates the first effect dominates. We will clarify this in the revised manuscript accordingly.

6859, Lines 4-5: The authors should explain in how far the conceptual model admits a multi-hazard perspective, since it does not become evident in the text.

We apologise for being too vague. Better wording will be used: “a systematic and consistent assessment of multiple hazards”.

6860, Lines 1:3: From the results presented in this study I can follow this conclusion. However how does this finding relate to other studies identifying high sensitivity to hazard strength, particularly in case of the most severe events. I believe this finding relates to the assumption that macroscopic damages are comprised as linear sums of individual damages on the microscopic level, which in case of large portfolio leads to diminishing uncertainties.

We will further discuss the interaction with related studies in the revised manuscript. Our results (see p6859 lines 19-23) actually show that overall hazard strength, or magnitude, is the dominating source of uncertainty for the portfolio (extrinsic uncertainty). This, of course, is in line with the reviewer’s reasoning. In the given example, however, we only discuss intrinsic uncertainty, where we consider the effect of local fluctuations at the building level. The reviewer may have been mislead by the sentence: “Uncertainty due to local hazard fluctuations or variations in hazard threshold (modelled as exceedance uncertainty) show significance only for low hazard magnitudes”. A better more precise wording would be: “Uncertainty due to local threshold exceedance (being a combination of local hazard fluctuations and local variations in hazard threshold) shows significance only for low hazard magnitudes”.

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