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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Economic assessment of measures aimed at reducing flood damage to buildings using computer modelling and expert judgement" *by* Claire Richert et al.

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Dear Referee,

Thank you for your comments and for the references you suggested. We reply to each of your remark below.

General comments:

In the first paragraph, you point out that the novelty of our article relates to the application of a new synthetic model to assess the cost-efficiency of several precautionary measures.

We think that the novelty of our article lies both in our research question and in our results. However, we agree that the current version of our article does not emphasize it enough and that we should explain it more clearly in the abstract, introduction, and conclusion.

We explain in the following why we think that our research question is original.

The purpose of the other articles that deal with the assessment of precautionary measures is mainly to examine their mean efficacy (or cost-effiency) in specific contexts. By contrast, we aim to present in-depth analyses of how these efficacy and cost-efficiency vary depending on the buildings characteristics and exposure to floods. Such analyses are useful in order to better target the dwellings for which precautionary measures could be advantageous.

We also think that we provide new and useful results. Mainly, we present a systematic methodology to identify the conditions (in terms of exposure to riverine floods) in which the measures cannot be cost-efficient, no matter the building materials. We apply this methodology to identify these conditions for the whole France. This result can be used by decision-makers to recommend precautionary measures only to inhabitants that live in dwellings for which precautionary measures could be advantageous.

In the second paragraph, you underline that we should refer to empirical and synthetic models which use precautionary measures or other building properties to explain flood loss, and that could therefore be used to make similar analyses.

We agree that we should compare floodam to existing flood loss models in order to explain why it seems to be the most relevant to conduct our analyses. Thank you for suggesting some references. We propose to add the following section, called "Suitability of floodam to assess the precautionary measures" after "3.3 Overview of floodam":

"Numerous empirical and synthetic flood loss models exist. Floodam belongs to the latter category. Empirical models are based on observed flood loss data, whereas

synthetic models rely on a description of flood damage mechanisms (Gerl et al., 2016).

Some empirical flood damage models include precautionary measures as explanatory variables (see for example Kreibich et al. (2017)) and can be used to estimate their mean efficacy (Sairam et al., 2019). They account for the mean effect of all measures in the sample used to produce them on flood damage. Thus, they cannot be used to estimate the efficacy of specific precautionary measures. Moreover, the influence of the flood parameters and building characteristics on the efficacy of precautionary measures cannot be deduced from these models.

The damage mechanisms are more explicit in synthetic models (see for example Custer and Nishijima (2015), Dottori et al. (2016), Nadal et al. (2010), and Zevenbergen et al. (2007)). They can be altered to depict the effect of specific precautionary measures. Floodam has one main advantage over the other existing synthetic models to assess the efficacy of precautionary measures. To our knowledge, no other model is based on such detailed database of elementary damage functions. This enables us to examine the influence of a wide variety of building materials on the efficacy of specific precautionary measures."

We should also specify in section "3.3 Overview of floodam" that floodam is used to estimate the damage due to floods that do not cause failure of walls and that do not involve salt water.

Moreover, we should compare our results with those of Zevenbergen et al. (2007) in Section "5.2 Comparison with previous studies".

In the third paragraph, you suggest to restructure the article to give more emphasis to floodam and present our analysis as an application of this model.

In our view, floodam is only a tool to analyse the cost-efficiency of some precautionary measures. The aim of the paper (that we should state more clearly in the introduction) is really 1) to examine how the building characteristics and flood parameters influence

the efficacy and cost of the measures and 2) to identify exposure levels for which the measures cannot be cost-efficient. Floodam is thoroughly described in its manual, which is free, publicly available, and written in English. However, in the article, we agree that we should more clearly explain why floodam is more suitable than the other flood loss models to examine the cost-efficiency of precautionary measures. As explained above, we intend to add a section after Section 3.3 to do so.

Specific comments: Your first comment is the following: "The first is related with the calculation of the annualexpected efficacy (AEE). In P2-L8 the authors correctly state the AEE can be obtained through a probability weighted average of the values of efficacy for different flood intensities. However, it is not clear in the article how the authors have actually calculated this. The probability of exceeding certain flood intensity measures such as water depth depends on the asset location, and as such, the average annual losses are site-dependent. Therefore, the cost-efficiency of precautionary measure is necessarily also site-dependent. What was considered here?"

Thank you for this comment. We agree that our explanation was not very clear. Indeed, the cost-efficiency of a precautionary measure is necessarily site-dependent. However, we wanted to find exposure levels for which each measure is not cost-efficient in general, independently of the flood intensity linked to these exposure levels. Thus, we found a supremum of cost-efficiency (that we call "maximum cost-efficiency") for each measure and each type of building (single storey house, double storey house, apartment). This supremum is not site-dependent because it is not calculated with the Annual Expected Efficacy, but with a supremum of the Annual Expected Efficacy. This supremum is the ratio between 1) the maximum efficacy of the measure over all possible combinations of water depth and submersion duration, and over all combinations of building materials, and 2) the return period of the flood that affects the dwelling the most often. The first term is constant and thus, not site-dependent. The second term is not fixed. It is the one we are interested in: we explored its influence on the maximum cost-efficiency to find exposure levels for which the maximum cost-efficiency is

negative. In these cases, according to our results, the measure will always be cost-inefficient, regardless of the building materials and the relationship between the flood intensity and flood frequency, since the maximum cost-efficiency is already negative.

In order to explain this better, we propose to add at the end of Section 3.5.3: “Indeed, unlike the cost-efficiency, the maximum cost-efficiency does not depend on the building materials and on the relationship between the flood parameters (water depth and immersion duration) and frequency. It only depends on the time horizon and return period. Thus, when the maximum cost-efficiency is negative, it means that the strategy will always be cost-inefficient, regardless of the building materials and on the relationship between the flood parameters and frequency.”

We also propose to make equation (4) more explicit: “AEE = int_{0}^{1} f x E(de(f), du(f)) df” with de the water depth and du the flood duration.

Your second comment is the following: “The second comment relates to the applicability of your findings. I assume these are meant to apply to France, but no explicit reference is made to this aspect in the article. In the abstract you also mention some findings (e.g. “according to our results, dry-proofing and elevating a dwelling are unlikely to be cost-efficient for dwellings that are not exposed to floods with a return period lower than 100 and 30 years, respectively”) but a reference to where they are assumed to be valid is missing.”

Thank you for pointing this out. You are right. We should add the following sentence at the end of the abstract: “Our results apply to France because the damage and the cost of the measures are specific to France and the geometry of the dwellings considered to perform our analyses is based on French dwellings.”

We should also add a sentence about this issue in Section “5.4 Limits” and in the conclusion.

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