Comment on egusphere-2022-225

Answer to Anonymous Referee #3

This paper presents an approach to calculate flood losses to residential buildings using a Source-Pathway-Receptor-Consequence model. The proposed approach is applied to an area of Milan, Italy which is frequently impacted by flood events. The authors apply the approach to a historical flood event that occurred in 2014 and three flood scenarios. The vulnerability of residential buildings is mapped, and damage curves are derived. The proposed approach has merit and the results are interesting, however, the paper is at times hard to follow and would benefit from some changes before publication. I have outlined my suggestions below.

We thank the reviewer for his careful reading of the manuscript and his constructive remarks. We have taken the comments on board to improve and clarify the manuscript. The vast majority of those have resulted in an addition to the text or to a change. Please find below a detailed point-by-point response to all comments (Referee's comments in black, our replies in red).
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Major general changes:
- *Modify the abstract to reflect clearer the scope of the paper;*
- *Added a clearer 'Background' and 'Aims' sections;*
- *Provided more detail on the Methodology throughout the manuscript;*
- *Ensuring a consistent results interpretation in the Discussion;*
- *Enhanced the figures.*

Specific Comments

Figure 1: what does the blue outline represent in the right panel in Figure 1? Is it the area of inundation or the study boundary? It would be useful to add a label describing this area to the map legend.

Reply: *The blue outline in the right panel of Figure 1 represents the 2014 flooded area that also corresponds to the study boundary. Following the Referee advice the authors added a label to the map legend.*

Figure 2: this figure needs to be improved. Only the source and the pathway symbols are easily understood. It is not clear what the receptor or consequence arrows are referring too. At the very least, the figure description needs to be improved so that the image can be understood on its own. I would suggest also improving the figure to make it more understandable.

Reply: *Figure 2 has been merged with Figure 3 to make the workflow of the SPRC model clearer and for consistency concerning to the study applied methodology.*

Line 134: What digital terrain model are you using?

Reply: *We have added that "FwDET identifies the floodwater elevation for each cell within a flooded domain based on its nearest flood-boundary grid cell here derived from the Digital Terrain Model (DTM) of the Lombardy Region with a resolution of 5 by 5 meters (Bocci et al., 2015)."*

Line 139: "This model analyses the DTM with hydrology…". What does this mean? Please expand on the approach.

Reply: *The sentence has been rephrased for clarity and a brief model description has been included as follows:*

'This model is based on the screening of a digital terrain model for landscape depressions and their maximum extent when filled up at the capacity before spilling over during a flood while ignoring local infiltration rates and time, thereby allowing the model to select buildings inside or adjacent to these low-lying areas'

Line 143: resampled using what approach? From what resolution?

Reply: *Resampling approach and layers resolution have been included as follows:*

'Therefore, the Copernicus High Resolution Layer Imperviousness Degree 2018 with a resolution of 20 m resampled by nearest-neighbours at 5 m is used to identify most exposed residential buildings'

Equation 1: Is the denominator supposed to be Building Footprint Area?

Reply: *Yes, it is. We change the denominator from 'Building Footprint' to 'Building Footprint Area' for clarity.*

Line 179: What is the reasoning behind assigning a building with a basement a more favourable weight than a building without a basement?

Reply: *The assignment of weights refers to the building's response capacity against flood hazard, meaning the capability or incapability of an object to resist the flood impact. Hence, lower values correspond to lower response capacity (high vulnerable buildings), whereas higher values correspond to higher response capacity (low vulnerable buildings).*

Section 3.2.1: How sensitive is the final score (and thus your outcomes) to the assumptions you make about the weights? For example, the choice of how many weights you assign to each factor has an impact on results. Are these weights taken directly from the literature? It would be good if the authors could elaborate a bit further on this.

Reply: *The assignment of weights for the heuristic approach refers to the building's response capacity against flood hazard, meaning the capability or incapability of an object to resist the flood impact. Hence, lower values correspond to lower response capacity (high vulnerable buildings), whereas higher values correspond to higher response capacity (low vulnerable buildings)(Table 2). The weights assignment have been given by authors based on an intensive literature review and on data availability. For indicators like Construction Material, Period of Construction, Building Status ranges like 1-9 or 1-4 were chosen, following the study of Corradi et al. (2015). In virtue of the possible methods (statistical assessments such as Principal Component Analysis, factor analysis, or participatory approaches like Analytic Hierarchy Process or Budget Allocation Process) an approach using equal weights by Taramelli et al. (2015) was selected, which represents the most adopted*

approach in literature (Beccari 2016; Papathoma-Köhle 2019). These indicators are identified as significant and suitable vulnerability indicators in urban areas representative of three components, i.e., flood hazard intensity, effect of the surrounding environment and building characteristics. A final total score for the heuristic approach is calculated by summing up all the weights assigned to each indicator composing a residential building, and classifying them in 5 categories, from 'Very High', to 'Very Low' vulnerability (Rincon et al. 2018, Gatti, 2020) using the Jenks Natural Breaks algorithm. With natural breaks classification (Jenks) Natural Breaks Jenks, classes are based on natural groupings inherent in the data. Class breaks are created in a way that best groups similar values together and maximizes the differences between classes. In addition, a different consideration was made to buildings with and without a basement. Here the aim was to set up the main vulnerability indicators based on the SPRC chain based on hazard intensity, building surrounding and buildings intrinsic characteristics. Overall, because of the method selected, the model output is quite sensitive to assumed levels of parameters. A robust sensitivity analysis would be a further step.
Furthermore additional and detailed information have been also added to the manuscript as follow:

'Age and maintenance are also indications for the current state of the building. Moreover, an estimation of elements-at-risk costs is fundamental to express losses in economic terms. The heuristic approach is based on a simple equal weights assignment procedure (Taramelli et al., 2015). The weights assignment have been given by authors based on an intensive literature review and on data availability. The indicators are identified as significant and suitable vulnerability indicators in urban areas representative of three components, i.e., flood hazard intensity, effect of the surrounding environment and building characteristics.'

'For buildings falling in most vulnerable classes (i.e., class 1 and 2, 'Very High' and 'High') a distinction was made between elements with and without basement (Arrighi et al., 2020; Molinari et al., 2020) assigning a weight of 0 to the building with basement and 1 to the building without basement (McBean et al., 1988; Crigg and Helweg, 1975). As previously mentioned, the assignment of weights refers to the building's response capacity against flood hazard, meaning the capability or incapability of an object to resist the flood impact. Hence, lower values correspond to lower response capacity (high vulnerable buildings), whereas higher values correspond to higher response capacity (low vulnerable buildings) (Taramelli et al., 2015).'

Beccari, B.: A comparative analysis of disaster risk, vulnerability and resilience composite indicators." PLoS currents, 8, https://doi.org/10.1371/currents.dis.453df025e34b682e9737f95070f9b970, 2016.

Corradi, J., Salvucci, G., and Vitale, V.: Analisi della vulnerabilità sismica dell'edificato italiano : tra demografia e " domografia " una proposta metodologica innovativa, 1–22, 2015.

Gatti, I.: Disaster risk assessment for urban areas : A GIS flood risk analysis for Luján City (Argentina), M.Sc. thesis, The University of Tokyo, Japan, 75pp, 2020.

Papathoma-Köhle M, Cristofari G, Wenk M and Fuchs S: The importance of indicator weights for vulnerability indices and implications for decision making in disaster management, International journal of disaster risk reduction, 36,101103, https://doi.org/10.1016/j.ijdrr.2019.101103, 2019.

Rincón, D., Khan, U.T. and Armenakis, C.: Flood risk mapping using GIS and multi-criteria analysis: A greater Toronto area case study, Geosciences, 8, 275, https://doi.org/10.3390/geosciences8080275, 2018.

Taramelli, A., Valentini, E., and Sterlacchini, S.: A GIS-based approach for hurricane hazard and vulnerability assessment in the Cayman Islands, Ocean Coast. Manag., 108, 116–130, https://doi.org/10.1016/j.ocecoaman.2014.07.021, 2015.

Figure 6: I can’t make out what categories half the box plots belong too because they are so small. Also, the text is too small to be read on the smaller maps. Please adjust the figure.

Reply: *The figure has been improved to make it clearer.*

Technical Errors

Line 25: consider replacing “it” with “one”

Reply: *Done.*

Line 40: “location” should be “location’s”

Reply: *Changed.*

Lines 64-66: Sentence beginning “Vamvatsikos” and ending “various scales”. I would consider rephrasing this for clarity

Reply: *The sentence has been rephrased for clarity as suggested by the Referee as follows:*

‘Some authors stressed the need of the use of empirical data from past event to provide powerful analytical tools (Vamvatsikos et al., 2010; Apel et al., 2008).’

Lines 135-134: Sentence beginning “Specifically,” and ending “near them”. I would consider rephrasing this for clarity

Reply: *Authors have rephrased the sentence as suggested by the Referee as follows:*

‘We investigated endanger urban residential areas located within or near landscape sinks (SI) that are potentially filled in conditions of flooding and inefficient drainage system (Dietrich and Perron, 2006; Dodov and Foufoula-Georgiou, 2006; Nardi et al., 2006; Taramelli and Reichenbach, 2008; Thrysøe et al., 2021).’

Equation 2: Period of Construction is shortened to “PC” in the equation but to “PT” in the preceding text. Change one to maintain consistency.

Reply: *Authors changed the abbreviation from “PC” to “PT” in the preceding text.*

Line 212: “Fig.1C “ in the text is labelled “Fig C1” in the Appendix. Please change for consistency

Reply: *Authors changed in Fig. C1.*

Figure 10: It seems the labels for figure 10b and Figure 10c are the wrong way around.

Reply: *Caption of Figure 10 has been corrected as follows:*

‘Figure 10: (a) Absolute Damage for the residential sector (n° of buildings) considering 500, 100 and 10 years of return period and the 2014 flood event; (b) Site-specific depth–damage curve for the residential sector considering 500, 100 and 10 years of return period and the 2014 flood event; (c) Exceedance probability of Absolute Damage for the residential sector.’