Reply on RC2

Jorge León et al.

Author comment on "Modelling geographical and built-environment attributes as predictors of human vulnerability during tsunami evacuations: a multi-case-study and paths to improvement" by Jorge León et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-309-AC3, 2022

We thank the reviewer for his/her comments. It follows detailed replies to each of them.

• In general, the paper is well written, and methodology and results are clearly presented. However, introduction of 4 pages seems to be too large and makes it difficult to identify the main focus and scientific gap to be researched. It would be convenient to shorten the introduction. In addition, since the main topic is the human vulnerability, I suggest to shorten the paragraphs from lines 36 to 66, since specific explanation of fragility curves may not be necessary.

A: We understand the reviewer's suggestions. While we decided not to shorten the Introduction section (as we considered relevant to deliver a comprehensive review of the state-of-the-art on tsunami human vulnerability), we enhanced this section with further references, and a more specific focus on how this vulnerability relates to the attributes of the geographical and built environments.

• Figure 1 should be in methodology. A new figure 1 should show a map of South America, Chile and the topo-bathymetry of each location in order to have an idea of the morphology of each city.

A: We moved Fig.1 to the Methodology section. We included a new Fig.1, as requested by the reviewer. Page 5, line 138 (in the old manuscript).

• The Figure 1 (new figure 2 in section 2.1) should show the tsunami arrival time instead of just the inundation area.

A: We modified this figure to also include (for each case study) the tsunami arrival time.

• Section 2.2.1 should include a figure with example of simulation grids and all tsunami scenarios used in the analysis.

A: We included a new figure to show the simulated seismic scenarios used for the case studies. In page 8, line 175 (old manuscript).

• Even though the resolution of the tsunami simulation is 4m, it would not be necessary to use the same resolution for the agent-based simulations. Since the inundation was

recorded every 10 min (line 174), this measure can give you a necessary resolution for agent-based simulations. In fact, several resolutions may be used and similar results should be obtained.

A: We understand the suggestion made by the reviewer. However, the modelling technique used the STOC software, which couples tsunami and evacuation models, therefore using the same grid with a unique resolution. This feature makes unfeasible to execute the agent-based model independently using a different grid size.

• Line 174 indicates that numerical model record the time series, however this results are not shown in the paper. The tsunami wave forms are also important to analyze the tsunami arrival time and whether you captured the maximum inundation. Please add a figure to show those time series.

A: We included a new figure showing the tsunami time series, for each case study. Page 8, line 177 (old manuscript).

• Line 172. Please clarify why only 45 min of elapsed time was used. It is well known that Talcahuano has some resonant effect and maximum tsunami inundation take place after several hours. In addition, it has been observed that the second or third wave are usually the largest one.

A: We understand the suggestion made by the reviewer. Indeed, local effects may lead to several hours of sea level anomalies. Nevertheless, preliminary modelling tests showed that evacuations in every case study would not take more than 36 minutes to complete. Therefore, we set up a 45-minute threshold to conservatively encompass the total evacuation process, regardless of longer tsunami effects. We included further explanation of this in the manuscript. Page 8, line 173 (old manuscript).

• Line 322. Only 0.74% of cells in Talcahuano show to have elevated dead ratio. It is not unexpected since the inundation given in figure 1 is not that large. What would be the result if you analyze the maximum tsunami inundation instead of just 45 min?

A: As we pointed out above, our methodology uses a coupled tsunami-evacuation model where both phenomena develop along the same timeline. Therefore, if the maximum tsunami occurs after the evacuation was complete (in the case of Talcahuano, roughly 27 minutes after the tsunamigenic earthquake), no extra casualties will occur. Of course, this might change if we change the model's assumptions, such as the evacuation departure rate.

• Line 340. I understand that from an evacuation point of view you are interested in the first tsunami front. This may explain why you used only 45 min. However, in 45 min, some areas may have 2 or 3 tsunami waves, while Talcahuano would have only one. It would be necessary to use the same criterion for all locations.

A: Please see our answers above.

• Lines 346. It is observed that average number of casualties would occur within 300 m from coastline. It would be interesting to analyse the effect of distant to trench, due to the fact that this variable affect tsunami propagation and subsequently the tsunami arrival time. Therefore, cities in northern Chile would experience larger number of tsunami-caused deaths than cities in central or southern Chile. Is that correct?

A: We understand the suggestion made by the reviewer. It is possible that other geomorphological variables, like the distance to the trench, can influence the expected death ratios. Nevertheless, it is hard (without a full new statistical analysis) to isolate the

importance of that single variable, having into account that (as our analysis showed) other features (like the street network configuration) also vary from case to case and have an impact on evacuation times and, therefore, the survival rate. We included in the Discussion section a list of other variables that could be included in further analyses. Page 16, from line 385 (old manuscript).

• Line 399 indicates that maximum flood was analysed, however, with 45 min of simulation some cities may not reach the maximum inundation. As indicated in comment 5, Please add a figure of tsunami waveforms in the results section in order to show that maximum tsunami flood was analyzed.

A: We included the requested figure (page 8, line 177, old manuscript). Also, we included changes throughout the manuscript to underline that we examine the maximum flood within the evacuation threshold of 45 minutes.