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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Variable population exposure and distributed travel speeds in least-cost tsunami evacuation modelling" *by* S. A. Fraser et al.

Anonymous Referee #1

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General comments:

This paper addresses the estimation of population exposure and travel speeds in least-cost distance (LCD) tsunami evacuation modeling. The method is applied to a case study of local-source tsunami evacuation in Napier City, Hawke's Bay, New Zealand.

Since the mentioned evacuation factors have been applied as static values in previous LCD approaches, the Authors justify the need for this research in order to include their potential variability in evacuation planning. The aim of the paper is to demonstrate a method for introducing variability in population exposure scenarios, evacuation depar-

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ture times and travel speeds into an anisotropic LCD model of pedestrian evacuation potential. The paper includes (1) an introduction; (2) a description of the study area; (3) a description of the methodology for the analysis of the anisotropic least-cost path distance, the time-variable population exposure and the evacuation time; (3) a discussion of the main results, as well as (5) some final conclusions.

The article is well written and based on an in-depth understanding of the evacuation's main concepts. It provides an interesting assessment of spatio-temporal human exposure which is a key issue on tsunami risk assessments and tsunami evacuation modeling, not being usually analyzed so exhaustively. This is in the main contribution of the paper, the findings on travel speed or evacuation departure time being less relevant, in my opinion. Nevertheless, the evacuee density maps provided are useful. Even if the spatio-temporal exposure distribution is interesting, the applicability to other study sites is difficult to see, so further efforts need to be done.

Specific comments:

The work deals with an enormous amount of data and very detailed analyses but I am not sure about the benefits of the results or the applicability of the method compared to previous simpler approaches. Such amount of needed information makes difficult to replicate it in other areas world-wide as well as to update the results once new data is available. Maybe the proved benefits of this method compared to others should be explicitly mentioned.

It is clear in the text that the Authors focus on improving the evacuation planning, and that providing the number of people unable to evacuate facilitates planning of additional evacuation and emergency response solutions; however the paper is not clear enough regarding what the product provided to someone responsible of the evacuation planning of Napier would be. The amount of information generated could be useful but is not practical for a manager. Further contribution is suggested on this issue.

Besides providing the specific numbers (i.e. results) for the Napier study area, it is

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important to think on the international readers who are more interested in the potential applicability of the method to their study sites than in the results obtained here. Clear conclusions should be extracted and provided together with the results.

Regarding the structure of the paper:

Following the argument in the paper is sometimes confusing due to the structure of the text. There is one section for methodology and one for results; however, some of the results are partially provided in both sections. The same happens with some figures: Fig. 3, 4 and 6 are mentioned continuously in both sections, so the first time the figures are presented you have not read all the related text yet. Figure 4, for example: the first time that Fig.4 is mentioned (page 4175, Method section) only part of the figure (4a) is explained and no conclusions at all are provided. The scenarios modeled and the results for Fig 4b and 4c appear in page 4179, and the results for Fig. 4-d-e-f are in the next 3 pages, everything already in the Results section. This should be improved somehow, maybe combining both sections in one, or just explaining at the beginning what the reader is going to find.

The 12 selected scenarios are described too late in the text (page 4179). Figure 4 is presented in the text in page 4175 and shows results for some scenarios, but it is not possible to understand the figure as the reader cannot understand the scenario-coding for the graphs (d2, e12, etc.). The same happens with Fig. 4-d-e-f, as they show results that have not been mentioned yet in the text.

.Regarding the exposure distribution:

The analysis regarding the location of the different population groups along the day is more accurate than others in literature. The population-time profiles are quite interesting information. However, the overwhelming amount of population data and the various criteria assigned makes difficult to think on its applicability to other study sites since the used data might not be easily available in other places and due to the assumptions considered. A table resuming the distribution of population groups by time

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and location, including the percentages applied (e.g. 60% at home/facility, 40% at unspecified location), would help having the entire picture of the proposed exposure distribution analysis.

Do the mentioned percentages applied respond to expert criteria? Or site-specific characteristics? This is not justified enough and should be mentioned in the paper, explicitly clarifying that these percentages might not be valid for other case studies (other countries, etc.).

Figure 2: the population-time profiles for independent/dependent elderly and visitors are not provided, why?

Regarding the evacuation speeds:

The Authors state that the analyzed evacuation factors (population exposure, departure time and travel speed) have not been adequately addressed in previous LCD approaches. However, after working with and analyzing such amount of information, the use of a static speed value of 1.1ms-1 is accepted in the Results section as providing a reasonable assumption to estimate the population unable to evacuate. This speed value is for sure consistent to many of the previous LCD approaches that have been considered inadequate in the paper. This indicates that more complexity does not translate here into better results. The same might happen with the other evacuation factors. I suggest avoiding the expression “not adequate” when this has not been really proved.

To estimate the evacuation speeds the walking speeds identified in previous literature are grouped into one of the five proposed travel speeds groups and associated to one of the five population groups (POPULATION GROUPS: 1. Working-age adults, 2. School/childcare, 3. Dependent elderly, 4. Independent elderly, 5. A proportion of individuals and groups who might run; TRAVEL SPEED GROUPS: 1. Adult unimpaired, 2. Child, 3. Elderly, 4. Adult impaired, 5. Running). Having this in mind:

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The calculation of the proportion of individuals and groups who might run rather than walk in an evacuation seems to be too detailed and maybe unnecessary analysis. In fact, the authors decided to omit it from some scenarios (page 4178).

According to the Authors, the travel speed distributions for elderly and impaired adults could be combined with minimal impacts on the results (page 4173). However, both curves and the subsequent analysis are maintained separately. Instead of simplifying the analysis based on a justified result, the Authors keep the complexity to demonstrate the functionality of the proposed method. More complexity does not translate into better results.

As resumed before, the proposed travel speed groups are: 1. Adult unimpaired, 2. Child, 3. Elderly, 4. Adult impaired, and 5. Running. If the Running group has been omitted from some scenarios, and the distributions for Elderly and Impaired adults could be combined with minimal impacts on the results, then the proposed 5 travel speed groups could be reduced to 3, i.e. adults, child and elderly, which is not so different from those previous references rated as inadequate. This should be mentioned or, instead, justify why the 5 classes are maintained.

Only age has been considered to estimate the evacuation speed of these population groups; however, several references consider disabilities in population as a factor hindering evacuation speed. The Authors have translated this disabilities category in Table 1 into adult impaired, but the data used to calculate it is only related to independent elderly, disabilities in the entire population not being considered at all. Please justify why this factor has not been included.

Table 2 shows the travel speed statistics for each travel speed group, compiled from travel speeds in literature, which are shown in Table 1. It seems that n (in Table 2) indicates the sample size for each travel speed group; represented by the number of times it appears in Table 1. The values of n in Table 2 for Adult impaired, adult unimpaired, child, elderly and running are 7, 19, 3, 11, 3, respectively. However, checking Table 1,

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I would say that n should be 5, 15, 3, 9, 1. Please clarify this.

Technical corrections:

âĂćPage 4182, line 15: there is a mistake when referring to the figure (Fig. 4g); it should be replaced with (Fig. 6g). âĂćFigure 4: PVE should be described in the figure caption

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