AUTHOR COMMENT: We would like to thank the reviewer for their consideration of the manuscript and constructive comments. We have clarified our points and responded to each comment below, and made amendments in text where required; any amendments are indicated in our responses below.

Referee Report

Paper title: Variable population exposure and distributed travel speeds in least-cost tsunami evacuation modelling

Overall comments:

I had a quick view on the paper and I must say that I was overwhelmed about the detail of elaboration which, on one hand, is quite appreciable; however, on the other hand, I have strong doubts about the practicability. The whole paper has probably a highly theoretical value, in the sense that some kind of sensitivity analysis is done with a huge number of parameters inside.

Aim of evacuation should be to evacuate all (or a maximum of exposed people). Aim of an evacuation plan should be to reach this aim and provide with proper means and to identify potential bottlenecks.

From a practical point of view, such an evacuation plan should rather focus on worst-case scenarios taking into account those parameters that create bottlenecks: the maximum of exposed people, the elderly, schools and hospitals, but also surface of the road, width of the road (not discussed in the paper). The distinction between night, weekend evacuation, the probability (40% 60& etc.) that young people run faster than expected, etc. is rather of theoretical nature instead of practical nature. There can be many possible scenarios but only one evacuation plan.

Therefore this paper has an interesting theoretical value but little practical value (at least, I cannot see it in a quick view); the paper should rather be published in a mathematical journal, I would even say.

AUTHOR RESPONSE: We agree with the reviewer's statement of the purpose of evacuation planning, and that the sensitivity testing presented here could be seen as theoretical. We believe that the paper has practical implications for evacuation modelling because we primarily demonstrate the use of an improved least-cost distance methodology that incorporates variability in population exposure, travel speed and departure time. The sensitivity tests are included to highlight the importance of the time phases included, and to quantify the reductions in average evacuation time on improvement of behavioural responses (i.e. increase in travel speed, reduction in departure time).

The paper seems to have considered a huge (and sufficient) number of literatures. The graphical part seems to be quite nice; it is understood well and all figures and tables are referenced well.

The conclusions are well structured. Interestingly, in the conclusions new aspects are mentioned or introduced which could be of huge importance (see last paragraph, lines 521 – 529). This left me as a reader a bit perplex, as many of these points are equally decisive for evacuation preparedness.

AUTHOR RESPONSE: We agree that these aspects are important, and should not be introduced for the first time in the conclusions. We have included the following sentence in the final paragraph of the

Introduction, to highlight the importance of these aspects, and the fact that they are omitted from the current methodology, in order to prime the reader and reduce confusion in the conclusions: '*The importance of traffic modelling, network capacity issues, evacuee interactions and disruption to evacuation routes due to earthquake damage are recognised; however, in order to focus on modelling the variability in exposure, departure and travel phases, these aspects have not be incorporated into the demonstrated process.*'

Specific comments:

In line 84 you mention arrival time; I guess it is tsunami arrival time.

AUTHOR RESPONSE: We have clarified this in text as 'tsunami arrival time'

At the end of chapter 4, line 470, you introduce bicycles. So what? Does it mean to introduce another parameter, like probability of certain population groups to use a bike, or availability of bikes per cell? I mean, you can endlessly introduce new parameters into your sensitivity analysis. I my opinion better stick to evacuation on foot.

AUTHOR RESPONSE: Bicycles were introduced as an example of a means to decreasing travel speed in addition to increasing walking speed, in terms of probability of certain population groups to use a bike. We acknowledge that the introduction of this concept at a late stage of the manuscript can be confusing, and we have tried to clarify that this is not additional parameter in this analysis, but that is *could* be considered in the same way: *'This approach could also be used to quantify the potential benefits of increased bicycle use in evacuations, to determine whether it is worthwhile trying to increase the use of bicycles in evacuation.'*

You do a very detailed analysis by introducing a variety of parameters, but then – sometimes – you step back: for example, the introduction of certain scenarios is a method to limit the range of results.

AUTHOR RESPONSE: The exposure scenarios presented in the paper are designed to demonstrate a range of possible scenarios, rather than to limit the range of results. As the method allows a user to choose any given scenario, it is necessary to present a limited subset of all possible exposure scenarios here. Rather than aiming to limit the analysis, the scenarios presented in sections 4.2-4.4 are designed to demonstrate the utility of the methodology in determining the maximum population exposure, and to show how consideration of a daytime and night-time exposure may not be sufficient to capture the maximum exposure in some areas that receive high levels of commuter traffic, for example.

Or as another example, in chapter 4.2 you discuss the omission of decision-making and preparation time: first you introduce these parameters and you omit them. So what?

AUTHOR RESPONSE: This section is included to demonstrate the requirement of including departure time in evacuation modelling, which has not always been included. Only by omitting the departure time and comparing with analysis of evacuation time *with* departure time, can we demonstrate the large time cost incurred in the departure time phase. To clarify the purpose of this brief results section, we have added a sentence to the beginning of this section: '*To demonstrate the importance of including evacuation departure time in evacuation modelling, analysis was conducted with the decision-making and preparation time phases (ID_t + EP_t) omitted.*'

As a third example, I would like to mention the mentioning of a mean ETi (in line 276); again, first you do an extremely detailed analysis and then you shrink yourself to a mean value. So what?

AUTHOR RESPONSE: The detailed analysis is repeated 500 times to obtain a mean evacuation time for each person while taking into account the variability in each travel speed/departure time distribution. The mean values for each person are aggregated to generate the mean evacuation time curve for the modelled population, with a measure of uncertainty around that mean curve. So, although we conduct the analysis to obtain a mean evacuation time, the uncertainty measure is retained and used in the estimation of the population evacuation curve.

And finally, there are some banal expressions like in

line 340: these ranges … variability in walking speeds. Isn't this obvious? What about those people who cannot walk at all?

AUTHOR RESPONSE: The point of the sentence is that the high variability in walking speeds has not been adequately represented previously, so when the whole sentence is considered, we feel that this is valid to retain in the text. We have, however, altered the sentence to hopefully improve clarity: 'These ranges represent variability in walking speeds that has not been captured by previous studies that apply a fixed speed to each category.'

Regarding the second point: It is true that we do not include a category for immobile people. We capture large concentrations of relatively immobile people by assigning the 'adult impaired' travel speed to those people in elderly carehomes and the remaining elderly population who live at home. The travel speeds for all people in a carehome reflects the slow moving nature of those who are able to travel faster, but help and travel with the mobility impaired people. Additionally, each of the travel speed distributions allows for the selection of travel speeds close to 0 m/s (see fig 3). By sampling travel speed from these distributions, the potential to represent immobile people does exist.

line 468: These results show the tangible impact that is possible due to an increase in travel speeds. OK, this is obvious. If you lash on people … they probably run faster.

AUTHOR RESPONSE: This section is included to quantify the impact of increased running speeds, further than just saying that 'increasing running speeds decreases evacuation time'. The sentence being queried is intended to state plainly to the reader, that increasing travel speed can have an important impact on casualty estimation. Whilst it can be seen as an obvious statement, we feel that stating this clearly is beneficial in the summary of results presented.

line 517: It has been demonstrated that a reduction in departure time can significantly reduce evacuation time and …. . Isn't this clear from the beginning? Do we have to demonstrate this scientifically? Mathematically?

AUTHOR RESPONSE: This is clear from the beginning, however, we feel that it is worthwhile to re-iterate the point in the conclusions. The demonstration of this point in the paper can benefit the reader / practitioner by quantifying the potential reduction in these scenarios and this method of analysis.

Language/grammar comments:

Language and grammar seem to be quite good, also seen the predominance of English-mother tongue authors. Personally I discovered the following point as difficult to understand or simply as being wrong:

In the abstract: "previous models have generally used two static … or have been used using two static ..

AUTHOR RESPONSE: We have corrected this from 'generally used using two static' to 'generally used two static'.

Line 119: has been made …

AUTHOR RESPONSE: We have corrected this from 'has been have been made' to 'has been made'.

Line 134: define three types of location …

AUTHOR RESPONSE: We have corrected this from 'type' to 'types'.

Between line 10 and line 198 you have a couple of [1]. What does it mean? Where is the reference?

AUTHOR RESPONSE: These refer to a footnote on page 5 (line 157), which identifies the source of statistics data as: '[1]Source: Statistics New Zealand, customised report and licensed by Statistics NZ for re-use under the Creative Commons Attribution 3.0 New Zealand license'. The first instance of the footnote is at line 137 on p.5, repeated thereafter at lines 180, 182, 190, 198. We will ensure that the footnote is incorporated in any later proofs of the manuscript.

Line 525: I would add a "to": this contributes to …

AUTHOR RESPONSE: We have altered this to '…this represents…'