

Interactive comment on “Rapid flood risk screening model for compound flood events in Beira, Mozambique” by Erik C. van Berchum et al.

Anonymous Referee #2

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Berchum et al. present a rapid flood risk screening model (FLORES), with an application to Beira. The study is interesting, and the tool itself seems very useful and worthy of publication. However, in its current form there are several major aspects that I believe would need to be addressed in order to consider further for publication. These are summarized below, followed by specific review points afterwards.

1. My main comment is with regards the main focus of the paper. It is unclear to the reviewer whether the main purpose of this paper is to present the overall framework of FLORES, with an example demonstration in Beira to enrich this presentation; or whether the application of the framework in Beira is in itself the main aspect of the paper. In the case of the former, the framework needs to be more thoroughly described, whilst in the case of the latter, more details on the application would be required. It is

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my understanding that the main aim is to present the framework (see paragraph on objectives and scope). However, it is then confusing that the authors state that the framework is already presented in Van Berchum et al. (2018). If the framework is already presented there, one could ask why another paper is needed to describe the framework. Therefore, this should be clarified. That said, I do see value in using this paper to better document this very interesting and certainly useful tool as a paper in NHES, and so I would encourage this. However, I believe that it should then be able to read it as a standalone paper, without having to flip back and forth with an existing paper. 2. For the application part (Beira), I would like to see more details on the data used in this specific case. For example, what vulnerability curves are used? What measures are implemented, etc. – see other examples in the specific points. 3. The results section is very shallow and needs more depth. Some figures are shown, but they are difficult to follow and require more interpretation in the text. On the other hand, a lot of results are interpreted in the text without actually being displayed in the figures. See examples in the specific review points below. 4. The title points to a compound analysis, but there is actually little focus on this in the manuscript. Indeed, the model can include pluvial and storm surge flooding, which is great. But I miss an attempt to place this within the growing scientific literature on compound flooding. It is not conceptualized in the introduction, and there is little reflection on this aspect throughout the manuscript. 5. More generally, a lot of the references used are rather outdated. 6. I would recommend a careful proofreading – below I list several typos but there are many more that could be listed.

Specific review points – L21-22: Floods are currently the most recurring and damaging type of natural hazard, posing major threats to socio-economic development and safety of inhabitants (Adikari and Yoshitani, 2009): this is a rather outdated reference for the claim being made. Is this still the case in 2020 and can this be supported by a reference from 2009? – L23-24: As both social-economic activity and extreme weather events are increasing, it is not surprising that vulnerability to flooding is growing rapidly (Doocy et al., 2013): Whilst the first part of the sentence seems okay, the

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second part states that vulnerability to flooding is growing rapidly. But is this really the case? There is ample literature to suggest that vulnerability may actually be decreasing in many regions (e.g. Bouwer and Mechler, 2015; Jongman et al., 2015; Tanoue et al., 2016; Kreibich et al., 2017). “These developments were made possible through highly schematized regional layouts that limit computational load. They are, however, a less accurate representation of the situation in a specific coastal city.” Please clarify what is meant here: less accurate compared to what? “In recent years, several of these models have been developed, mostly for particular case studies (Gouldby et al., 2008; Aerts et al., 2014; Shen et al., 2016).” Again, given the rapid expansion in the field, these references are not so “recent” to back up the “in recent years” claim. In the Methods section, it is explained that “At the heart of the model is a flood simulation model, that calculates the extent and resulting impact (i.e. economic damage, amount of people affected) of a flood, represented by a storm with a specific return period (Figure 1).” What do the authors mean here in the context of compound flooding? A given storm can have a storm surge and rainfall with quite different return periods, and an essential question of compound flood analysis is how to deal with this, yet I miss this here. “The schematization of the storm surge is based on van Berchum et al. (2018)”. Please expand here, given that this is an exposee of the framework – I also did not find much elaboration of this element in the cited paper. Example of more details needed: the manuscript talks about the “probability of failure being taken into account”. But how is this done? What curves etc? “Maintenance cost is not taken into account, but can be included as a fraction of the construction cost.” This confused me. Here it first seems like the framework does not take it into account, but the second half of the sentence indicates that it is taken into account. “using the definition of risk as expressed by Kaplan and Garrick (1981).” Please state what this definition is, rather than expecting the reader to go and look up the definition. “By varying the intensity and return period of the incoming hazard, the risk profile shows how the city and the implemented measures perform under different circumstances” Indeed, this is an im-

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portant aspect: explain here how this is done in a compound sense (i.e. the different kinds of hazards need to be both varied and somehow combined). It is stated that “A common problem of risk analysis of compound flood events is correlation between the flood hazards (Wahl et al., 2015). Several types of large storms, such as cyclones, generally lead to both storm surge and rainfall. Considering the hazards separately and independently would be underestimating the potential risk. Although complicated, correlation can be estimated based on historical data and expert judgement. In many countries, this data is not or only sparsely available. In FLORES, the risk calculation can be adjusted based on correlation.” More detail of this method is needed. It is good that the risk calculation can be adjusted based on the correlation, but please explain how this is done. What method is used? Section 2.1.3 states that there is a flood risk reduction strategy screening component. However, I miss an explanation of how it works. What strategies are included that the user can choose from? What methods are used to implement them? How are they parameterized? Section 2.2 is also rather vague. It is stated that the tool should work on limited data, but I would like to see a description of what the minimum data required are, for example in the form of a table. Section 3.2.2 “For this particular case, first analysis using ERA-Interim (Dee et al., 2011) suggests independence between coastal storm surge and extreme rainfall, which was therefore also used for this screening.” The methods need explaining. What is this “first analysis” – how was it carried out? In Table 2, the maximum surge level is stated, which as far as I can include also includes tide. Usually, the surge level is only the surge component (i.e. without tide). Why not refer to something like still water level? (i.e. average water surface elevation at any instant, excluding local variation due to waves and wave set-up, but including the effects of tides, storm surges and long periods)? This is a semantics question, but what is meant by “improve the flood resistance of Beira”. In what sense is the word “resistance” used? In section 3.2.3, a “few examples” of measures in Beira are stated. But as a reader I want to here read and understand the actual ones that are used in the model. What combinations? How are they schematised etc? Similar to the previous comment,

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for the reader it would be valuable to know the values used for the maximum damages, the forms of the vulnerability curves, etc. There is a reference to the report of Huizinga et al., which is a good starting point. However, the data from Huizinga would still need to be transformed to the current case study – I would like to see this kind of information, for example in a Supplementary Information section. In section 3.3 it is stated that there is very limited validation. Whilst this is understandable, please provide the results of the benchmarking exercise that you did carry out. Where are there differences? What are the possible causes? The results in section 3.4.1 are too brief. For example I would like to see a table with the impacts for the different combinations. Later on, I noticed that this is what is shown in Figure 7, but that is in a section called “Screening of flood risk reduction strategies” – suggest to move that here. L241: “As a result, damages due to compound flooding are more than the sum of damages of the individual flood hazards.” This is an interesting statement, but where do I see this in the results? I would like to see a table with the results for the different ones individually and together? Moreover, the reader does not actually see the EAD results, which should be added. L242-243: “Coastal storm surge is mostly problematic when resulting from a tropical cyclone. These situations do not occur regularly, which is why the effects of coastal storm surge only become significant for more extreme events”. Similar comment as above: where do I actually see this in the results? Section 3.4.2: what is a zero year event? Line 253+ “The resulting risk profile can be seen in Figure 7. Integration of probabilities and consequences of events result in the expected annual damage (dollar/year).” Indeed, but as mentioned earlier I would like to see these EAD results, and also some kind of summary table of the different measures/strategies and how much EAD they reduce. In the current state, I don’t actually have a clear understanding of what all the measures are that are implemented. Not until line 255 does the reader learn that the strategies are based on 500 randomly drawn measures. This should be in the Methods, including which measures they are drawn from and how this works. Figure 9 and related text talks about sensitivity using “feature scoring”. It is good that this is added, but again I miss

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this in the methods. How is this done? Are the things listed on the left the measures from which strategy combinations are drawn? There are some more statements where I cannot make out where the results are actually shown. For example, “Simulations show that retention areas are effective only for smaller pluvial events, but have insufficient capacity when a storm surge overpowers the coastal defenses and reduces the effectiveness of the drainage system.. This effect is increased because the high outside water level during storm surge events prevents the drainage system from functioning.”. Please show these findings and point the reader to them – more generally, please refer more clearly to the figures etc in the interpretation. Towards the end of the results (lines 275) a new analysis is then introduced. Again, this should be described in the Methods section. It is not clear to me at present how it works. For example, Table 3 has “design choices” in the heading. But what do you mean? What is a design choice? It has not been mentioned earlier. Does this mean an individual measures? And the strategy is a combination of measures??? Small textual comments As said previously, I would recommend a thorough proof-reading. A few (non-exhaustive) suggestions can be found below: L44: “High-resolution flood simulation software (e.g. Delft3D, SWMM, MIKE) has become standard practice. . .”. Change to: “The use of high-resolution flood simulation software (e.g. Delft3D, SWMM, MIKE) has become standard practice” L194 “Regarding the elevation data, this LiDAR DEM data developed as a part of an earlier project financed by the World Bank, aiming to enhance local research.” It seems like there is a missing word in this sentence? Several locations: use “number of people” instead of “amount of people” L218 “little data is available”. Change to “few data are available” (also check other instances of data, should use plural) L236: Capital letter “between” L251: “there performance”. Change to “their performance”

References Jongman et al., 2015. PNAS, doi: 10.1073/pnas.1414439112 Kreibich et al., 2017. Earth’s Future, doi: 10.1002/2017EF000606 Mecher & Bouwer, 2014. Climatic Change, doi:10.1007/s10584-014-1141-0 Tanoue et al., 2016. Scientific Reports, doi: 10.1038/srep36021

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