Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2018-234-AC2, 2018

Interactive comment on "Integrated risk assessment due to slope instabilities at the roadway network of Gipuzkoa, Basque Country" *by* O. Mavrouli et al.

O. Mavrouli et al.

o.c.mavrouli@utwente.nl

Received and published: 12 November 2018

Q1. The manuscript presents a quantitative / qualitative procedure to assess hazard and vulnerability and their integration into risk calculations for roads by considering four different hazardous processes: rockfalls, retaining walls, slow moving landslides, and coastal erosion induced failures. The work is well written and the subject of the manuscript is of interest for NHESS, however, the manuscript needs some moderate revisions before to be accepted to be published.

A1. We would like to thank the Reviewer 2 for his/her comments and insights, which helped us a lot to improve the quality of the manuscript. We tried to take all the suggestions of the Reviewer into account and prepared a new version integrating them.

Q2. Major comments: The manuscript is basically focused on the hazard evaluation, using quantitative and mainly heuristic approaches. The cost of direct road and retaining structures are not explored along the work, as they were obtained directly from the regional administration.

A2. The approaches followed, except for the risk related to sea walls is not heuristic, instead it is based on analogs and proportionalities for calculating the probability of occurrence of the events of a given magnitude/intensity which is assessed based on quantitative data. Most of the procedures for risk assessment are based on analogs. As for example, the most well-known approach, which is the Rockfall Hazard Rating System follows the same logic, as it assigns the same level of risk to slopes showing similar geometric and geomechanical features. In our work, for the rockfall hazard, we followed such a logic, starting from the slopes with F-M available and assigning these values to slopes showing similar characteristics. This assumption is not restrictive but justified on the grounds of geomechanical characterization and its relation to the hazard, as for the RHRS mentioned above. What we would like to stress here, is that the criteria established for the quantitative risk assessment proposed here are transparent, reproducible, and they are based on quantitative data. The cost of repair for roads and retaining structures was obtained by the co-authors engineering companies and regional administration, based on real repair costs, by previous interventions. Its calculation is based on the works that have to be made for each types consequences. These works are explored and detailed in the Table of the Annex. We think that it is no use for the readers to the actual costs in monetary terms here, as these prices fluctuate a lot, according to location and time.

Q3. The few works worldwide dealing with both direct and indirect costs resulting from road damage by landslides have shown that indirect costs can be orders of magnitude higher than direct costs. Although authors clearly state they do not address indirect costs, this topic should be highlighted in the discussion section of the paper.

A3.We agree with the Reviewer. Indeed indirect costs are very significant when calculating economical loss due to landslide road disruption. We highlighted this section in the discussion section as suggested by the Reviewer.

Q4. The methodological section of the manuscript is well balanced, but section 4 is not very well balanced. Section 4.5 (overall results and discussion) is poorly developed when compared with the description of the 8 studied cases for which the risk was calculated. The discussion can be enlarged and improved namely by incorporating the sensitivity analysis of the heuristic options used to assess the hazard. The conclusion section also need to be improved. The ïňĄrst six paragraphs are not conclusions but a summary of the work.

A4. We enriched the discussion section, with comments related to the uncertainties which are included in the proposed procedure. A sensitivity analysis, showing in quantitative terms the effect of the uncertainties in the estimation of the risk components and the final risk would require systematic information on the data quality, which we do not have available. For this reason, and according to the Reviewers′ most useful comments, we included some comments on the most important uncertainties involved in the analysis. As for the conclusion section, we tried to eliminate information which is repeated in the text, however we have left the most important results from the application.

Q5. Minor comments References are missing along the description of the geology of the study area (Page 6. Line 9 – 18).

A5. The references for the geology of the study area are provided in page 5.

Q6. Page 6 – line 6-8 The text is not clear. Explain better the relationship between lithology and landforms in the study area.

A6. It was rephrased.

Q7. In section 2, authors should provide the number of Points of Risk corresponding to each considered hazardous process (rockfalls, retaining walls, slow moving landslides, and coastal erosion induced failures). The relevant information is provided in the manuscript only in section 4.4 (page 29).

A7. Done

Q8. What is the difference between hazards and instability mechanisms that are referred in caption of table 2? Table 2 is not very much informative. Authors can provide the number of PoR considered for each instability mechanism class considered.

A8. The reviewer is right. As part of this information is repeated in the Appendix, we deleted this table.

Q9. In the ïňĄrst part of section 3 - General Methodology for the Risk Assessment, authors should state that different procedures are used to assess magnitude and frequency for the processes that are presented in the next sections.

A9. Done

Q10. Figure 3 is nor referred in the text.

A10. We added reference for Figure 3 in the text.

Q11. Table 3 – How relates the events indicated in table 3 with the 95 PoR referred before? Are some of them the same? It is not clear.

A11. Please note, that as we deleted the part referring to the failure of sea walls, we are now referring to 84 PoR instead of 95 in our manuscript. Out of them 20 concern rockfalls. These latter are distributed in the entire network and not only in the sections of the road N-634. The events indicated in Table 3, instead refer only to the 5 PoR of the road N-634. This was clarified in the text too.

Q12. Page 10, line 1-4 The typical size of slope face is uniform? To each extent a scale effect may control the extent of observed discontinuities in the rock mass?

A12. The slopes have in principle an altitude of few tens of meters and large lateral extension, up to tens and hundreds of meters. As a result, there are no persistence limitations due to topography.

Q13. In table 5 The maximum IF should be ïňĄxed as 9?

A13. Indeed. This was also indicated in Table 9, in the revised version

Q14. Page11,line1-3,Authors state: “To assess the expected frequency of a given rock[fall] size, the total expected number of events is distributed over the rockfall volume classes, as observed in situ. If this datum is lacking, the proportion of a modal size of blocks multiplied by the total annual frequency is suggested instead. The statement is not enough clear. Please, provide more information regarding this topic.

A14. This part was rephrased to: During the in situ inspections, data is collected for the relative frequency (%) of potential rockfalls, per volume class and for the most frequently encountered rockfall size on the slope (modal). The annual number of events per volume class is calculated by multiplying the total annual frequency with the relative frequency of each class. If the relative frequency data has not been collected, risk calculations are made, for the modal size, as an average approximation.

Q15. Page 12, line 2 “The six magnitude classes”, instead of “the ïňĄve magnitude classes”. Apparently, some data is missing in table 7. It is not clear which score applies to ‘yes’ / ‘no’ for the project and construction. Therefore, it is difïňĄcult to solve equation (5).

A15. The Reviewer is right. “Five” was replaced by “six”, as it is six classes. There are three possible scores for PQ. 1 if “available data for anchors” is yes and “Technical assistance during construction” is yes, 3: if “available data for anchors” is no and “Technical assistance during construction” is yes, and 5: if available data for anchors” is no and “Technical assistance during construction” is no.

Q16. Page 17 , line 17-23 Rainfall is not continuous in time neither in space. Please, provide where the rainfall data was registered. Also, authors state that the rainy period of January-February 2013 that was characterized by moderate to low daily intensity but of long duration, with cumulative precipitation measurements that exceeded the maximums of the reference period 1971-2000. How many weeks refer the long duration?

A16. Rainfall data that is mentioned here was collected at the Añarbe Dam (inside the study area). Unfortunately, we do not have available official data for the exact number of rain days in this period, as it also depends on the location inside the study area.

Q17. It is not clear the way authors obtained the intensity classes referred in table 11.

A17. The four intensity classes were established so as to correspond to the four damage classes in Figure 5, which in turn correspond to different repair costs. Damage levels were related with the intensity classes, based on observations of the damage on the road and the inclinometer indications.

Q18. Page 22, line 15 Table 12 instead of Table 16. Concerning the sea wall failures, is there any relation between the annual probability of failures and the magnitude (size) of the failures?

A18. After the suggestions of Reviewer 1, this section was removed. In any case, to provide an answer to Reviewer 2, there is no relation between the annual probability of failure and their size.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-234/nhess-2018-234-AC2-supplement.pdf

---

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2018-234, 2018.