General/Specific comments:

- *This paper presents an open-source web GIS platform designed for conducting risk assessment and cost-benefit analysis of mitigation measures. It is an additional paper in a series of papers already published with a similar content (see e.g. Aye et al., 2016c). The tool follows the method, which has become standard in Switzerland for prioritizing mitigation method by the Federal Office for the Environment. As such the presented method is not new. RISKGIS appears to have an appealing design. The project seems to have a lot of potential to make courses on geohazard risk more interesting and hands-on. This supports the generally effective "learning by doing" approach, while better preparing students for work after university. As such the work is very valuable in the education of future natural hazard specialists.*

Thanks for your comment on the potential of our project. Regarding the referenced paper *Aye et al., 2016c,* we would like to clarify that this paper is not merely an additional paper with similar contents which we already have published before. RISKGIS was carried out in a different project, and it was rather oriented to teaching and learning in risk management of geohazards. It was based on our previous experience in testing the prototype of *Aye et al., 2016c* with students (which was designed for real experts and decision makers). The results of *Aye et al., 2016c* served as one of the motivations, and RISKGIS is developed using open-source technologies by taking the advantage of our previous research works.

For clarification, new features of RISKGIS are listed below, compared to the prototype of *Aye et al., 2016c*. In this study, RISKGIS is specifically designed for:

- certain courses and practical exercises in university for education;
- risk concepts and methods applied in Switzerland;
- rapid risk estimation based on qualitative (vector) hazard intensity map and OpenStreetMap data;
- cost estimation of measures;
- manually edition of new input maps for risk estimation (such as hazard intensity and buildings map);
- cost-benefit calculation of different risk mitigation scenarios and
- additional features such as registration, customized data sharing and interfaces for students and teachers.

Besides, pedagogical scenarios for progressive learning are designed and implemented in this study, starting with the rapid risk calculation and moving on to the more complex risk management concepts incorporating real events of natural disasters as case studies. In addition, test quiz, group assignments and various questionnaires are integrated via the Moodle platform for the purpose of evaluation.

- *However, I doubt the scientific contribution of this paper, which is one of main goals of NHESS. Furthermore, the scientific quality is poor, since this paper only describes the tool, its application in case studies and the response of students regarding the performance of the software. The conclusions of students are similar to conclusions already published in Aye et al., 2016c, which reads as "could be further improved". Therefore, the novelty of this paper could be questioned. Although the paper is well structured and concepts and exercises are described in detail so that the reader can get a good idea of the tool and the students' work sequence, I cannot recommend the publication unless substantial scientific findings are included in the paper.*

Even though methods applied are not new, RISKGIS can be considered as a new, simple and practical tool for students studying environmental risk beyond the traditional (paper-based or desktop GIS) approach, which is currently being used in the classroom. As we mentioned in Sect. 2 of the manuscript, due to the spatial nature of risk, it is often difficult to deal with realistic, geographically large and complex cases on paper in exercises. With RISKGIS, students can not only learn approaches used by experts but also gain insights in complexity of risk management through real case examples. Besides, through role-playing, students have an opportunity to experience different roles and perspectives of stakeholders in risk management. This is supported by four moments of

experiential learning theory (Kolb, 1984). Moreover, thanks to its advantage of being a web-GIS, it can be easily accessible from a web browser without needing to install additional GIS software. Notably, it can be freely adapted and reproduced as necessary due to its open-source modules and technologies, which is beneficial to the scientific, academic and open-source community in natural hazards. Some of its benefits are already highlighted by the reviewer, and yes, this tool could indeed be adapted for real decision makers in natural hazards and risk (as asked by the reviewer in the supplementary file). *Aye et al., 2016c* was the kind of tool meant for real decision makers in risk management, and in RISKGIS, we adapted it for students but with approaches used in Switzerland for relevant course exercises. As the reviewer questioned, we are also currently working on a web-GIS application for Canton Vaud authorities in Switzerland for risk management of natural hazards.

The findings of this research are strengthened and supported by feedback collected from students and observations in classroom. Probably in this current version, we did not formulate enough to highlight main contributions and findings (as also pointed out by another reviewer). We will revise it accordingly in respective sections. However, compared to *Aye et al., 2016c* and concerning the novelty of RISKGIS, in this research, the focus is placed on teaching and learning (as already explained and listed above). Thus, this study is different from *Aye et al., 2016c*. We are also using RISKGIS in this academic year, based on the feedback we obtained from students last year. Hence, there could again be improvements for the next year, considering it is an iterative and cyclical process in applying the platform with students.

- *As our comments indicate, the used terminology should be critically checked since it is not used consistently throughout the paper. Additionally, please have a native speaker do a detailed revision of the language. Text flow and comprehension need to be improved.*

Thanks for your kind suggestions and corrections. For the revised paper, we will make sure that the terms are consistent (such as "exercises" instead of "scenarios", which can be confusing as the term "scenarios" was also used to describe risk and alternative scenarios, for example, in exercises). We will also check the language so that the readability and flow of the paper is improved.

Further comments:

- *Especially for key vocabulary, choose one term and stick with it throughout. E.g. protection measures – why confuse the reader with "alternatives"? Or "scenarios" for "exercises" – simply use exercises in the whole paper to keep things clear.*

In RISKGIS, we use the term "alternative" as a combination of protection measures, i.e., to specify that there can be different protection measures in an alternative. We will revise accordingly so that the reader will not be confused.

- *Give a brief description of the Innovative Teaching Project.*

The Innovative Teaching Project (2016) is funded by the Innovative Teaching fund (Fonds d'innovation pédagogique) of the University of Lausanne, and the underlying question of this project is "How does an environmental risk system work?". The first objective is to make students understand that the evaluation of risks depends on the knowledge of the system to be evaluated and on the level of expertise, and to become familiar with approaches used by experts in natural hazards. This project concerns two courses: Environmental Risk, and Advanced Quantitative Risk and Vulnerability courses. The Environmental Risk course (9 sessions per semester) sets the goal to introduce environmental risks and their implications on the society from a quantitative viewpoint, while the Advanced Quantitative Risk and Vulnerability course (7 sessions per semester) is dedicated to the in-depth understanding of risk notions for a thorough risk calculation of natural hazards and it presents methods of Swiss Confederation among others including expert approaches such as impact-probability matrices. During the courses, a series of lectures are delivered accompanied with exercises as part of each session such as different types of hazards

and risk, risk calculation, statistics applied to natural phenomena in risk assessment and so on. Particularly in the Environmental Risk course, previously in exercises, interactive (spatial web) tools such as RISKGIS were not applied. Exercises that involve risk calculation, cost and profitability of mitigation solutions were carried out using synthetic cases and on paper. This is where a web-GIS solution like RISKGIS comes to play a significant role in classroom, allowing not only students to visualize, analyze and compute spatial data for risk estimation and management but also teachers to develop more concrete exercises using real case studies. As a part of this project, the web-GIS platform (RISKGIS) is therefore developed and applied progressively in courses replacing some of the paper-based exercises throughout the semesters (2016). Three teaching scenarios involving the application of RISKGIS are designed to support progressive and experiential learning of students. First, students calculate risk starting from hazardous situations such as earthquakes, landslides and debris flows. The calculations involves the vulnerability, elements-at-risk and their values, people, etc. Then, students work in group by sharing their thoughts and knowledge during the process, with an objective of taking decisions and establishing a strategy based on cost-benefit and multi-criteria analyses. The risk reduction is assessed and evaluated by groups and discussed within the course, allowing students to also have the possibility to give and receive feedback by his colleagues and teachers. Combing this (online and offline) participative approach with role-playing activities, students have an opportunity to experience like experts in real world and can learn from each other. This brings innovative pedagogical practices and values to traditional curricula and classroom setting. The findings through the empirical evaluation (i.e. feedback of students and observations in classroom) supported aspects of experiential learning, in which the learning experience of students are improved through group work, collaborative interaction, discussion and hands-on participation.

We will revise the respective section accordingly for a better explanation of the project: its objectives, teaching scenarios, approaches and added values.

- *What is the purpose of the questionnaires concerning the group work (e.g. figure 15)? What do you learn from the answers and how is this information useful?*

The purpose is to understand aspects related to group functioning and decision making, particularly in the third stage of the third exercise. Students played the roles of different stakeholders in decision making for selection of alternatives. The first questionnaire is for the first round of selection, in which each group of students (same role) makes the decision within group. This is to analyze how students with same role behave in a group and how working together in a group can benefit them in decision making. The answers were as we expected, supporting our findings in group functioning. The second questionnaire is for the second round of selection, in which all groups of students (mixed roles) come together and discuss to achieve a final solution. Here, we want to answer questions such as who influences the decision making process in a mixed group with different roles of stakeholders. The feedback results were consistent, and through this process, students were also able to grasp the real situation, conflicting interests of stakeholders and the complexity of a group decision making process in risk management. We will include this explanation and findings in the revised version.

- *In the case of the Brienz case study: Was the real solution presented and discussed in class? That would nicely round off the exercise, showing students what was decided by the experts and explaining why.*

Thanks for your comment. That would really be a good round off. Particularly in the third exercise, protection measures taken in the study area was briefly presented and explained. For the second exercise, as they still have to submit a group report within three weeks (if a report is good, we give a bonus note to students), we did not present the real solution in the beginning. For example, in this year, we presented an example case along the actual one so that they can have an idea.

- *Could the tool be adapted for real decision makers in natural hazard risk? Perhaps that could be a future aim for the project.*

Yes, it could be adapted. Contrary to the reviewer's comment before, *Aye et al., 2016c* is an example of such tool for real decision makers. However, in RISKGIS, we adapted *Aye et al., 2016c* for students but with approaches applied in Switzerland for relevant course exercises. We are also currently working on an online tool for Canton Vaud authorities in Switzerland for risk management of natural hazards, under the framework of another project.

Technical corrections:

- *Page 1, line 1: "…with a free and…"*
- *Page 1, line 9: "…is developed for students studying environmental risk…"*
- *Page 1, line 10: "…become familiar with…"*
- *Page 1, line 12: "…hands-on…"*
- *Page 1, line 12: "…To identify the potential and practicality of the …"*
- *Page 1, line 14: "… semesters of the Environmental Risk and Advanced Risk and Vulnerability courses at the University…"*
- *Page 1, line 15-16: "…are conducted starting with the rapid risk … exercise and moving on to the more complex risk … exercise incorporating different case studies…"*
- *Page 1, line 17: "…are asked to take a test, complete feedback questionnaires or write group reports on the Moodle platform in order to evaluate the exercises, the RISKGIS platform and the performance of the students…"*
- *Page 1, line 20: "…of 64/100 are achieved…"*
- *Page 1, line 21: "…and feedback from the students…"*
- *Page 1, line 26: "...van Westen, 2013). Rapidly developing technologies such as GIS play an…"*
- *Page 2, line 2: "…achieving goals of science education such as utilisation of technology and development of…"*
- *Page 2, line 4: "…the evolution of the web and with the advancement of technology it has…"*
- *Page 2, line 10: Either "in teaching and learning" or "in instructional settings"*
- *Page 2, line 11: Accessibility to hardware: you still need a computer to access a webGIS, so how is the need for hardware reduced?*
- *Page 2, line 12-13: "…platforms can be easily accessed from…" or "…platforms are easily accessible from web browsers without purchasing GIS software. …"*
- *Page 2, line 12: "limited resources of the Lab": What resources, what lab? See suggestion above (p. 2, lines 12-13)*
- *Page 2, line 19-20: "interactive, active, activity" in the same sentence – try to eliminate at least one. E.g. "task" instead of activity*
- *Page 3, line 14: ..and in the following paper: Consider using "exercise" instead of "scenario" since scenario has a different meaning in the risk context.*
- *Page 6: line 20: Explain what you mean with "Jigsaw".*
- *Page 7: line 5-6: eliminate parentheses: either use the word or don't (exception: IRM).*
- *Page 8, figure 2 and rows 3-5: Choose more unmistakable terminology for the figure (and in general). E.g. instead of "alternative formulation" use "planning of measures" or "choosing a course of action". Also, make sure your explanation of the figure (rows 3-5) uses the same words as appear in the diagram. Add numbers to the figure so it is very clear which step is which and the reader doesn't have to do the matching herself."*
- *Page 8, line 10: What is meant by hazard layer? I would rather suggest the term "scenario".*
- *Page 9, line 8: The value 5000000 CHF needs to be further explained. I recommend to replace it with a factor since 5000000 CHF is a value used in Switzerland. The VSL approach reflects the societal willingness to pay for averting a fatality, which is closely related to a specific country.*
- *Page 9, line 11: 12 hours in each of 365 days per year.*

- *Page 9, line 15-21: The unit for individual risk should be 1/year in my eyes. It translates as how often per year, a particular person (a person living in object i) is likely to die. With the unit "deaths/year" you are suggesting that the individual risk says how many people die per year, which is what the collective risk (non-monetised) is about. By using the unit 1/year, you can eliminate the irritating "1" in equation 3.*
- *Page 9, line 28-30: year in citation UNISDR is missing.*
- *Page 10-11, line 26-29: Use a variable (e.g. CBR) instead of an actual ratio (N/ K_{tot}) to name the cost-benefit ratio in equation 5. K(j) is confusing, especially since up until now, j has been the index for a particular hazard. Use K_{tot} throughout. Even if it is fairly obvious, explain R(before) and R(after) when you list your variables below equation 5.*
- *Page 11, line 14 and following: Alternative and criteria are not capitalised in this context.*
- *Page 11, line 23: Ideal not idea*
- *Page 11, line 20: Explain $L_p(x_p*)$ in equation 7.*
- *Page 12, line 10-13: Why are some words italic? Also the case in following lines.*
- *Page 12, line 23: What is the benefit of a remote area?*
- *Page 12, line 26: Wouldn't that be a return period of 500 years, then? 25 years may not make a big difference on that scale but it is confusing for the reader.*
- *Page 12, line 27: The term "location site effects" does not make sense.*
- *Page 14, figure 4: There should not be any red bars (even if they are very slight) for a 0 value. Use the word points (or an equivalent) instead of notes (in the text above and below the figure as well as in the figure itself).*
- *Page 14, line 6: As it turns out in line 11 and following, you are not asking questions but giving statements which students can agree or disagree with. Hence, please change the word "question" as well as the abbreviation "Q" for the statements (applies to the rest of the paper, too). Mention the Likert scale here as well, not only later on in the paper. It may give the impression, that you are using two different approaches.*
- *Page 14, line 9: You might mention that a SUS score above 68 is considered above average…*
- *Page 15, line 9-16: Consider putting these pros and cons into a bullet point list for a better overview. Consider it, too, for the presentation of the other results in the following paper.*
- *Page 26, line 12: This question does not fit well with the scale "not at all to absolutely". Consider rephrasing it or adding a second scale.*
- *Page 27, line 11: Explain your scale of 1 to 5 in words in the text, not just the figure caption. Again, not all the questions are suitable for "not at all to absolutely".*
- *Page 27, figure 15: Try to avoid 3D graphs.*
- *Page 28, line 23: Either use the word collaborative or don't but don't put it in parentheses – this makes for cumbersome reading.*
- *Page 28-29: A detailed repetition of the questionnaire results is not appropriate in the discussion. Generalise and mention only the key points. Also, the suggestion of the exercises running parallel to the course should not appear for the first time in the discussion – this belongs with the questionnaire results and can be briefly mentioned here as a potential future development for the course..*

Many thanks again for your corrections and suggestions. We will correct them as suggested in the revised paper.

- *Page 12, line 16: Why did so few students comply? Could it be that only a certain "type" of student took the quiz and answered the questionnaire, thus distorting your results?*

Because it was not obligatory for students to answer the quiz and feedback questionnaire in the first exercise. For example, during the third exercise, as there were only 13 Master students, the whole exercise was done on the same day and we asked students to fill questionnaires (in paper format) at the end immediately.

- *Page 20, line 19: Was the consideration of ecological aspects already part of this exercise?*

Yes, in the last stage of the third exercise. Different aspects (social, economic and environmental) are considered in the selection of alternatives. In this stage, students played different roles of stakeholders (in groups) and ranked alternatives based on their preferences on decision criteria.

- *Page 26, line 20: What is moderate, what is high severity?*

58% of students had conflicts in prioritizing decision criteria within the group. However, when it comes to the severity level of conflicts, on a scale of 1 to 5, only 38% of students gave a score of 3 (moderate) while no students indicated a score of 5 (high). We will rephrase it more clearly in the revised version.

- *Page 28, line 8: "…cost was the better choice despite the limitation of risk for human beings." I don't understand this argument.*

It was because cost was an important criteria for students who played the role of mayor, while the technician group considered it as the least important criteria in the selection of alternatives. This comment was given by students who played the role of geologists. Their alternative was ranked second marginally due to its cost, which was much higher than the winning alternative, while their alternative provided a better safety to affected people and buildings in the area. During the final round of selection, only if the committee led by the mayor agreed to weigh less on cost criteria, the alternative of geologists would have been selected. This means students clearly understood that there are trade-offs in selection, and that it is important to share a common goal among all involved stakeholders. We will include it in the revised version.