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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "A multi-scale risk assessment for tephra fallout and airborne concentration from multiple Icelandic volcanoes – Part 2: Vulnerability and impact" *by* C. Scaini et al.

Anonymous Referee #1

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General comments:

The presence of volcanic ash in the atmosphere has the potential to disrupt aerial navigation as well as causing significant socio-economic impacts from local to continental scales depending upon the intensity and duration of the eruption and the properties of the ash and atmospheric circulation. This paper focuses on a multi-scale vulnerability impact assessment of tephra fallout and dispersal from explosive volcanic activity in Iceland. The results from the study could support land use and emergency planning at both a national level and with regards to risk management strategies of the European air traffic system.

The authors acknowledge that recent research on vulnerability has recognised that it is a multi-dimension concept comprising different aspects: physical, social, economic, systemic, institutional environmental etc. In the paper, the authors have made it clear what aspects of vulnerability assessment they focus on, at both the national and regional (European) scale. This is useful because although studies conducted at a local level are valuable they may completely miss the relevant interconnections that are spatial, temporal, and systemic. The focus is therefore on the systemic and economic vulnerability of tephra fallout at the national scale for Iceland, and on systemic vulnerability of the air traffic system to tephra dispersal at the wider European scale.

The authors state that assessment of systemic vulnerability to tephra fallout and dispersal is quite new in volcanology research and there is a lack of specific studies on the vulnerability of Icelandic territory to tephra deposition. No vulnerability assessment of any air traffic system specifically focused on volcanic ash hazard is said to exist, therefore this high quality study fills a much needed gap in research. As the experiences from the 2010 Eyjafjallajökull eruption demonstrated, it is absolutely necessary to include tephra dispersal and deposition in any risk assessment of active volcanoes characterized by explosive activity.

Overall, the scientific and technical questions raised within the paper are within the scope of NHESS and the paper presents new data and methods to assess tephra fallout and dispersal; the findings are, in my view, of international standard. The study represents the first ever assessment of vulnerability for European air space for tephra dispersal. The scientific methods developed by the authors are clearly outlined and appear to be valid, although I must admit to no particular expertise either on volcanic activity or on air traffic systems.

The paper is logically and clearly structured. The title reflects the contents of the paper and the abstract provides a concise summary of the study and the results. The paper is quite long at over 30 pages. The publisher's guidance is for papers to generally be short but self-contained, although there are no page number restrictions. I have no

strong views on this as the paper gives a detailed account of the research and findings. Readers who may want to skip the details could read the Introduction, Discussion and Conclusions sections only.

I found the tables and figures to be useful in illustrating the authors' findings; for example the GIS maps provide a clear visual account of expected impacts of tephra dispersal on airspace sectors under different eruption scenarios. The number and quality of references cited in the paper are appropriate, as is the amount and quality of the supplementary material supplied. As a non-specialist in volcanic or air traffic research, I feel that the paper would be understandable to a wide and general audience, although it is possible that there may be some technical terms that may not be familiar to some readers. It may be worth the authors reviewing the article to make sure that all technical terms are briefly explained. The English language is overall of good quality and the paper is easy to read. There are some technical corrections that need to be made and some language queries that need to be checked which I have listed below.

Methods:

The methodologies employed by the authors appear to be sound and valid. For the national vulnerability assessment the authors have based their analysis on data from past events which identify the agricultural, transportation and energy sectors as the most vulnerable to tephra accumulation. The authors have therefore defined exposed targets for economic and systemic vulnerability within these sectors, estimated the vulnerability for each target and evaluated the expected impacts for all the eruptive scenarios defined in the previous hazard assessment that is presented in the companion paper. These methods provide useful results to assess vulnerability and inform decision making at the national scale.

The authors also propose three different methods for assessing the impacts of tephra dispersal on European air traffic, with each method focusing on producing specific results that could be used to support risk management strategies at different levels:

qualitative GIS-based visual overlap of hazard and vulnerability maps; impacts at given airports by multiplication of the average atmospheric persistence time of a given hazardous ash concentration for a given eruptive scenario; overlapping hazard and vulnerability data and combining the values on a cell-by-cell basis. The impact maps presented (and others prepared using the same methodology) could improve preparedness and help develop risk mitigation actions and support long-term risk management plans. The methods have the potential to help avoid secondary impacts such as the lack of fleet at non-contaminated areas during the closure of main airports, which have caused problems in past events.

The methodology developed has also allowed the authors to identify the Icelandic and European air routes that have the highest socio-economic significance. The paper is therefore also important because, as the authors note, the territorial context of an airport is relevant for the estimation of socio-economic vulnerability and impact. This is because the vulnerability of a region is proportional to its dependence on air traffic, particularly where areas have low multi-modal accessibility and where alternative transport modes may not be available. It is also important because tephra fallout may produce much higher secondary than primary impacts.

Concluding comments:

If the authors are indeed correct (and I have no reason to doubt their evidence) in that the most damaging tephra incidents during the last 60 years occurred within the first 1000 km from source volcanoes and within the first 24 hours after eruption onset, then the results of their impact assessment can support the definition of strategies for many stakeholders involved in air traffic management, and other sectors affected by air traffic disruption, during volcanic eruptions. Even though Iceland is said to be a highly resilient country, civil protection has traditionally focused on short-term reaction to volcanic events rather than on long-term land use planning. The research results could support longer-term land use and emergency planning at the national level as well as risk management strategies of the European air traffic system.

The results from the study are, in my view, sufficient to support the interpretations and conclusions of the authors. The methodology described in the paper should be able to be applied to other active volcanic areas, where necessary by adjusting for specific local contextual differences and thus enhancing the long-term management of tephra risk. For example, the exposed targets identified in Section 3.1 can be revised, as relevant, for other study locations and Table 8 which lists the type of data that, ideally, should be included in any comprehensive vulnerability assessment can be revised to reflect local contexts. This could include consideration of the seasonal character of vulnerability, as mentioned on page 2559, which may have important implications for activities such as agriculture.

The authors do acknowledge limitations in the current methodology, for example other aspects of vulnerability such as physical, social or institutional, are not assessed in the paper. However, it is proposed that the methodology presented is flexible and could be integrated with other types of analysis, such as more local level physical vulnerability assessment or risk perception and could therefore contribute to the development of a more comprehensive and enhanced multi-scale methodology. This would be useful as it would also be interesting to know more about the potential risk to health, for example for those people with existing respiratory problems, with regard to longer-term exposure to tephra fallout. This could then also be included in consideration of emergency response planning. The various types of vulnerabilities are not separated one from another, they actually influence each other. Therefore, for any future full assessment all aspects of vulnerability should also be considered.

Finally, there is a strong need to move from hazard oriented assessments towards more comprehensive approaches putting at the centre the vulnerability and resilience of exposed systems. In conclusion, I therefore feel that the manuscript discussed here represents a substantial contribution to the understanding of natural hazards and their consequences and provides new methodologies to help in this with regard to tephra fallout and dispersal from explosive volcanic activity.

Technical corrections:

Abstract: there are a number of minor grammatical errors that should be corrected to improve the abstract as follows:

Line 7: should read "... that accounts for the relevance of ..."

Line 13: expression could be improved as follows – "and allow the identification of the expected..."

Line 15: suggest revise as follows: "scenarios can disrupt the main electricity network, in particular in the case of eruption of the Askja volcano."

Line 20: "At the European scale, ..."

Line 26: scenario should be plural 'scenarios'; France should be 'France's'.

Page 2536 line 22: I think the authors mean 'uninhabited' here rather than 'inhabited'?

Page 2540 line 9: delete 'the' before 'so-called'.

Page 2540 line 14: same as above – my understanding of Iceland is that the central part of the island is mostly uninhabited rather than inhabited. Also check page 2560 line 21 where the term inhabited is also used.

Page 2540 line 15: delete 'a' before 15%, also on page 2543 lines 6 and 7.

Page 2540 line 20: 'cares' should be singular 'care'.

Page 2541 line 6: insert 'a' before 'railway'.

Page 2541 line 8: insert 'the' before 'mobility network'.

Page 2542 line 1: the word 'sparse' is not correctly used here. I think that the authors mean that the hydroelectric plants are spread across the country.

Page 2542 line 12: 'if the total' should be 'of the total'.

Page 2542 line 19: spelling error – ‘supllement’ should be ‘supplement’.

Page 2542 line 23 and page 2543 line 8: use of the word ‘aisled’ – as a native English speaker this is not a word that I am familiar with. Do the authors mean ‘isolated’ - as in isolated villages and farms?

Page 2542 line 25: I assume that ‘kettle’ should be ‘cattle’?

Page 2543 line 26: insert ‘the’ before atmosphere.

Page 2543 line 27: either ‘network’ should be plural – ‘networks’, OR it should read “Disruption of the road network, power plants . . .”.

Page 2544 line 20: insert ‘the’ before population.

Page 2545 line 7: ‘network’ should be plural ‘networks’.

Page 2545 line 8: ‘depending’ should be ‘dependent’

Page 2545 line 16: insert ‘in’ before significant’ – “can result in significant ...”

Page 2545 line 22: insert ‘for’ before ‘using’.

Page 2545 line 25: insert a ‘,’ after complexity and delete the following ‘and’

Page 2546 line 22: delete ‘in’ after ‘engulf’.

Page 2546 line 23: delete ‘the’ before ‘power plant’

Page 2546 line 26: suggest say either that ‘There is little evidence of tephra impacts . . .’ OR ‘There are few examples of tephra impacts . . .’.

Page 2546 line 28: delete ‘its’ after ‘produce’.

Page 2547 line 8: suggest revise as “the resilience of the population, used to coping with . . .”

Page 2548 line 28: insert ‘to’ after ‘used’.

Page 2549 line 19: delete ‘the’ before ‘European’.

Page 2550 line 10: delete ‘the’ before ‘Keflavik’.

Page 2555 line 5: delete ‘an’ before ‘alternative’.

Page 2556 line 29 and page 2557 line 3: do the authors mean the Shannon FIR rather than Shanwick?

Page 2562 line 10: insert a space between ‘support’ and ‘integrated’.

Page 2565 line 8: insert ‘the’ before ‘UK’.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 2531, 2014.