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Discussions

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Interactive Comment

Interactive comment on "Quantitative spatial analysis of rockfalls from road inventories: a combined statistical and physical susceptibility model" *by* M. Böhme et al.

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We would like to thank the reviewer for the suggestions and comments which help to improve the manuscript significantly. All the technical corrections suggested will be integrated into the final manuscript version.

We would like to highlight, that rockfall inventories covering larger regions are rare and those that exist have to be used, even if the quality might not be perfect. Against the accusation of the reviewer, there has definitely not been done any "twitching and fitting" of a susceptibility model neither of the training region nor other data. All analyses and also the final susceptibility modelling are strictly kept quantitative with as little expert input as possible. However, based on some comments it seems that the reviewer misunderstood at least some details in our manuscript, which we need to clarify better in a revised version.

In the following, point-by-point responses to the reviewer's general comments on the manuscript are given.

General comment 1 and 2: This manuscript shows as the first study, that a combination of statistically and physically based susceptibility models makes it possible to use road inventories, with registered rockfall impacts instead of sources, for susceptibility modelling. This combination restricts the statistical susceptibility map to areas that are steep enough to represent a potential rockfall source. In other statistical susceptibility maps, regions with low slope angles still get a certain susceptibility, while after our opinion the susceptibility for rockfall should be "0" for regions with slope angles that are too low that rockfalls can develop. On the other hand, a pure physical map is only binary. Thus it just outlines areas where rockfalls can physically originate from. Based on a physical susceptibility map, it will thus not be possible to differentiate between regions with low and high rockfall susceptibility. In addition to producing a susceptibility map, our aim was to quantify external and internal parameters that control the development of rockfalls in the study area. This is not possible with a physical model, and a statistical analysis is necessary.

Furthermore, until now, only a limited number of quantitative statistical susceptibility studies focus specifically on rockfall (e.g., Frattini et al., 2008; Marquínez et al., 2003; Marzorati et al., 2002; Shirzadi et al., 2012; Zahiri et al., 2006), compared to those studying landslides in general. To our knowledge there is only one publication (Zahiri et al. 2006) that is using Weights-of-Evidence for rockfall susceptibility mapping explicitly. Especially with respect to our new proposed approach we think that there is still the need for more quantitative susceptibility studies focusing on one specific landslide type.

In addition, this manuscript analyses significantly more and other parameters in order to produce a quantitative statistical rockfall susceptibility map, compared to existing studies, whereas important standard slope-morphological parameters, like slope angle or curvature, are excluded due to restrictions of the inventory.

General comment 3: As topographic parameters we use "relative relief" and "slope aspect" in the final susceptibility map. "Relative relief" is not sensitive to the exact location of the point, because it is defined as the difference in between minimum and maximum elevation within a circular window of 5km radius. This radius is significantly larger than the distance in between rockfall source and impact. Furthermore, the "Slope aspect" is not changing significantly in a down-slope profile, thus the travel path of a rockfall, given the usage of a 25m DEM.

General comment 4: It is right that there exists a 10m DEM for entire Norway. However, this is not entirely a "true" 10m DEM. Some parts are still based on the data from the 25m DEM, just interpolated. Furthermore, the physical rockfall susceptibility map was produced when only the 25m DEM existed. To ensure equal quality and maintain consistency we decided to also use the 25m DEM for our study. A comment about the limitations for the physical susceptibility map based on the DEM resolution is presented in chapter 3.3.

General comment 5: This is described in the first paragraph of chapter 7 and illustrated on Figure 3. However, we will add a reference to Figure 3 in the corresponding paragraph in chapter 7.

General comment 6: We are aware that climatic parameters are probably the most significant parameters controlling rockfalls, as we state in chapter 6.6. However, within this study, the analyses of the climatic parameters are strongly limited to available data covering the entire study area. The descriptions are adapted to the value of the results from the statistical analysis with respect to the usefulness for the susceptibility model. We could not find a clear and significant spatial trend in between existing climate data and recorded rockfalls based on the conducted analyses as described in chapter 6.6. We conclude that the used global averaged data might not be appropriate to capture the climatic influence. Using more detailed data is beyond the scope of this study and it might also be challenging to cover such a large area. However, we could include a paragraph in the discussion part where we discuss this in more detail.

The three categories for the normal annual precipitation are defined based on the results of the statistical analysis. These three categories do after our opinion best describe the observed quantitative spatial relation in between recorded rockfalls and precipitation data (see Figure 3f).

General comment 7: We are aware that there are more publications which might be relevant for our study, However, research articles in NHESS are limited to a maximum of 80 references, so that we had to limit the references to the most important ones. The current reference list is still slightly longer than this limit. Some of the references mentioned by the reviewer have actually been included in an earlier version, but were removed due to this limitation and considering them not as important as other references for the purpose of this publication. Especially, because we do not go into detail of the method for the physical rockfall susceptibility method, we do not see the importance to include more references regarding this topic.

General comment 8: Yes, we agree with this and this will be done.

General comment 9: The size of the figures/maps is a problem with the discussion paper format. The originally submitted pdf, which I prepared after the defined format from NHESS, has larger figures and details will be visible.

Can the reviewer please be more specific for the rest of the comment? Which figures should be improved? After our opinion the colouring is consistent. What are after the reviewer's opinion unnecessary descriptions?

General comment 10: This is a helpful suggestion and we will include this.

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Interactive Discussion

Discussion Paper

General comment 11: We will do this.

References:

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 81, 2014.