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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Landslide susceptibility mapping in Mawat area, Kurdistan Region, NE Iraq: a comparison of different statistical models" *by* A. A. Othman et al.

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General reply to the Editor "Landslide susceptibility mapping in Mawat area, Kurdistan Region, NE Iraq: a comparison of different statistical models" A. A. Othman, R. Gloaguen, L. Andreani, and M. Rahnama

Dear Editor, We want to thank the Editor for his considerate contribution and comments, which we believe have improved the quality of the manuscript. We have carefully checked all the comments provided by the referees and Editor. We have implemented the suggestions and tried to modify the paper in order to answer all critics.

REMARKS

Two independent referees have examined your submission, and have posted their comments online. You had an opportunity to respond to the comments posted by the referees. Overall, the two referees have identified a number of problems with your work, which they have outlined in detail. I share most of the comments of the two referees and I urge you to consider them very carefully. We thank the Editor for this comment. We have carefully checked all the comments provided by the referees and Editor. We have implemented the suggestions and tried to modify the paper in order to answer all critics. The revisions suggested by the first reviewer are highlighted in the manuscript in yellow and gray colors, while the revisions suggested by the second reviewer are highlighted in the manuscript in green and gray colors. The revisions suggested by the Editor are highlighted in the manuscript in brown color.

What is more warring is that the significance of your work, with respect to similar published work, does not emerge. It is not clear where the innovation is, and what is different from previous landslide susceptibility modeling studies. This has to be clarified for the paper to be acceptable. We thank the Editor for this comment. In the manuscript, we highlighted the innovation points of this work, which are (1) the use of carefully selected geomorphic indices. Those geomorphic indicators make a better job at describing the relief anomalies and, therefore, should provide better predictors of landslide susceptibility (lines #4-5, 172-173, and #560-580). (2) The second reviewer was mentioned in his report that this work focuses on the Mawat area of Kurdistan region, which has never been mapped for landslide susceptibility. We clearly stated that in the manuscript (lines #7-9, and 582-583). (3) For the first time, we compared between four landslide susceptibility mappings including frequency ratio, weight of evidence, logistic regression and probit regression, which has never been used before for LS mapping. The two reviewers already stated that in their reports and we clearly stated that in our manuscript (lines #68, 456-457 and 595-596).

Quality of the Figures is good, but can be further improved. Also, consider limiting

the number of the Figures to those really necessary to the discussion, moving other figures as ancillary materials. The same applies to the Tables, and specifically Table 2. We agree with the first reviewer, we moved both tables (Table 1 and 2 in the previous version) in appendices A and B. In addition, we moved three figures (Figure 4 to 6 in the previous version) as appendices C, D, and E.

Quality of the English and the technical language also needs to be improved. We agree with the Editor, we improved the English form (highlighted in magenta color).

Please consider carefully all the comments and suggestions of the two referees, and my editorial comments. With your resubmission, please provide a list of the changes made and a list of your responses to the comments of the referees and the editor. We thank the Editor for this comment. We have carefully checked all the comments provided by the referees and we have implemented the suggestions and tried to modify the paper in order to answer all critics. In below the two our responses to the comments of the referees:

General reply to the first reviewer (3-C381-2015)

REMARKS

In the entire paper, the authors use the term LSI landslide susceptibility index to refer to a probabilistic susceptibility. Landslide susceptibility is more appropriate to avoid confusion with susceptibility index-based estimation approaches. We thank the first reviewer for the suggestion; we used “landslide susceptibility” or “LS” instead of “landslide susceptibility index” or “LSI” to refer to probabilistic susceptibility (e.g. line #7, 19, 33, 36, 39, 52, 59, 67...etc.).

The landslide terminology in not always correct (e.g. triggering area in place of depletion zone, etc.). We thank the first reviewer for this comment; we put “depletion zone” instead of “triggering zone” (e.g. lines #27-28, line #300 and 302). Although some papers such as “Thiery et al., Landslide susceptibility assessment by bivariate methods

at large scales: Application to a complex mountainous environment, Geomorphology 92 (2007) 38–59.” used the term of “triggering zone” as well.

Some of the paper speculation on the susceptibility comparison are based on small differences in the susceptibility model performances: this can be critical in particular if not considering the possible uncertainty associated to the different susceptibility model. Basically the authors need to prove that the differences obtained using the different models are not within the modelling uncertainties. We thank the first reviewer for the suggestion; we tested the uncertainty associated to the susceptibility models. Two type of uncertainty were tested (1) Landslide susceptibility model error (Figure 7) and (2) Sensitivity analysis (Figure 8). Moreover, the method and outcome of these two uncertainty types were stated in lines # 339-350 and 489-505, respectively.

Moreover, the paper has two additional critical problems: (i) the authors make wrong use of ROC term, indeed they use this term to refer to success rate curves, (ii) the authors make wrong use of the term of validation to define model skill prediction performance measures. We thank the first reviewer for this information; we used the correct name, which are “Success Rate Curve (SRC)” instead of “ROC” (e.g. line #13, 320, 321. . .etc.) and “prediction skill” instead of “validation” for the whole manuscript (e.g. line # 317, 318, 324. . .etc.).

The tables in the appendix can be probably put in the text, in any case these need to be correctly numbered. We thank the first reviewer for this suggestion; we renumbered both table to be as appendices (Appendix A and B).

English grammar need a check, in particular the verb tenses are not correct in all the cases, probably the use of past tense in place of the present for describing what was done in the analysis is more appropriate. We agree with the first reviewer, we improved the English form (highlighted in magenta color).

COMMENTS AND SUGGESTION

Page 2 Line 26 The term erosion here in not appropriate, use the correct terminology (e.g. use depletion zone). We thank the first reviewer for this comment; we put "depletion zone" instead of "triggering zone" (e.g. lines #27-28, line #300 and 302).

Page 2 Line 31 Here and in the rest of the paper the authors use "landslide susceptibility index (LSI)" in place of the more appropriate "landslide susceptibility". In fact using the term index is misleading, since the authors in most cases intend to refer to probabilistic susceptibility values. I suggest to use here and in the rest of the paper the term "landslide susceptibility" We thank the first reviewer for the suggestion; we used "landslide susceptibility" or "LS" instead of "landslide susceptibility index" or "LSI" to refer to probabilistic susceptibility (e.g. line #7, 19, 33, 36, 39, 52, 59, 67...etc.).

Page 2 Line 34 Substitute "potential regions of landsliding" with "landslide prone areas" We implemented that (lines #35-36).

Page 2 Line 37 These are not "different mapping techniques" but "susceptibility estimation techniques" Exactly, we modified that (line #38).

Page 3 Line 63 "GIS techniques" is too general, please be more descriptive" We explained the GIS techniques, which used (lines #66-67).

Page 3 Line 63 Substitute "between four types of LSI mapping" with "the four landslide susceptibility models" We implemented that (line #67).

Page 3 Line 64 Something seems missing here. Please check the phrase. We modified the phrase (line #67).

Page 3 Line 66 Substitute "included" with "was organize following four main steps" We put "is organize following four main steps" instead of "included" (line #69).

Page 3 Line 67 Please rephrase "without any consideration of time the occurrences" We modified the phrase (line #70).

Page 4 Line 105 Substitute "The study area has frequent landsliding because of envi-

ronmental and/or human–induced reasons" with "Landslides in the area are frequent and they are mainly due to natural and anthropogenic triggers." We implemented that (lines #109-110).

Page 4 Line 108 Substitute "of" with "controlling the distribution of" We implemented that (line #112).

Page 4 Line 111 Something is missing here. Please rephrase. We modified that (lines #123-128).

Page 4 Line 113 The term "high certainty" is too general; please express these in a quantitative way. We agree with the first reviewer, we expressed about the identification of the landslides in a quantitative way (line #128).

Page 4 Line 116 How can you obtain a total landslide area of 3127 km2, having 351 and a maximum landslide area of 0.32 km2? Please check. We thank the first reviewer for this comment, we found that there is a "point" is missing within the total landslide area number; the number should be "3.127" (line #12 and 131).

Page 5 Line 143 Substitute "prepared" with "were prepared" We modified this sentence (line #154), but we substituted "prepared" with "were selected".

Page 5 Line 146 Substitute "The input parameters have two forms: discrete and continuous. The discrete form (group A) includes lithology, land cover and slope aspect, while the rest (group B) are continuous forms. We prepared the input parameters in two ways based on the applied model." With "The input parameters can be discrete and continuous: lithology, land cover and slope aspect (group A) are discrete, while the rest (group B) are continuous.". Here probably the distinction between categorical and numerical is more appropriate. We modified the phrase (lines #159-160), also, we distinguished between categorical (lines #162-163), and numerical (lines #165-166).

Page 5 Line 150 Substitute "to test" with "to exploit" We implemented that (line #161).

Page 5 Line 152 Substitute "to test" with "to exploit" We implemented that (line #165).

Page 5 Line 153 From here to the end of the section: not clear, please be more descriptive. We clarified the phrase and described the binarization more (lines #168-170).

Page 6 Line 158 Substitute “We used the following eight factors as geomorphological predictive factors of landsliding” with “In the susceptibility estimation we used the following eight geomorphological variables”. We modified the phrase (line #172).

Page 6 Line 159 “which is an important factor causing the landslides” please be more descriptive. We clarified that (lines #173-174).

Page 6 Line 163 the definition of aspect is not complete and the following sentence need to be rephrased. We removed the slope aspect definition because the second reviewer asked that.

Page 6 Line 166 The definition of slope curvature is not clear We removed the slope curvature definition because the second reviewer asked that.

Page 6 Line 174 Substitute “mapped the landslide susceptibility map” with “realized a susceptibility zonation”. We did that (lines #190-191).

Page 6 Line 181 TPI and HI are inverted in Equation (1) and (2) We thank the first reviewer for this comment; we modified that (Equation #1 and 2).

Page 6 Line 182 this is not true, TPI was used for instance by (A) Li, Y., Chen, G., Tang, C., Zhou, G., & Zheng, L. (2012). Rainfall and earthquake-induced landslide susceptibility assessment using GIS and Artificial Neural Network. Natural Hazards and Earth System Science, 12(8), 2719-2729. (B) Mohammady, M., Pourghasemi, H. R., & Pradhan, B. (2012). Landslide susceptibility mapping at Golestan Province, Iran: a comparison between frequency ratio, Dempster–Shafer, and weights-of-evidence models. Journal of Asian Earth Sciences, 61, 221-236. (C) Ozdemir, A., & Altural, T. (2013). A comparative study of frequency ratio, weights of evidence and logistic regression methods for landslide susceptibility mapping: Sultan Mountains, SW Turkey. Journal of Asian Earth Sciences, 64, 180-197. We thank the first reviewer for this information,

we modified that by removing “for the first time” from the sentence, and we put two citations suggested by the second reviewer (line #196).

Page 7 Line 208 Before “The precipitation” add “Form the daily data series we estimated the year precipitation. ”Which type of precipitation map? We modified the sentence to be “We averaged annual precipitation from the daily time series data.” (line #225).

Page 7 Line 209 here you probably use IDW to “interpolate the precipitation data” Exactly, and we clarified that (lines #225-227).

Page 8 Line 251 the definition of A is missing We thank the first reviewer for this comment; and we gave the definition of A (line #253).

Page 10 Line 290 Make the sentence more clear and use the correct terminology: e.g. depletion zone scarp. We clarified the sentence and we corrected the term to be “depletion zone” (lines #302).

Page 10 Line 300 In place of “landslide-present pixels” use “pixel with landslides” or “unstable pixels” and in place of “landslide-absent pixels” use “pixel without landslides” or “stable pixels”. We used “pixel with landslides” and “pixel without landslides” instead of “landslide-present pixels” and “landslide-absent pixels”, respectively (line #306, 309, 311, 312 and lines #311-312).

Page 10 Line 307 The reference for R is missing. We thank the first reviewer for this comment; we added the reference of R (line #315).

Page 10 Line 309 Here you are not doing a model validation but you are measuring the prediction skill of the model. Validation requires the application of the model in areas different from those the model were trained. We thank the first reviewer for this comment; we modified the term to be “prediction skill” (line #317).

Page 10 Line 312 Here you are indicating ROC curve (Fawcett, 2006), but what you are using is a success rate curve (e.g. see Chung and Fabbri, 2003) We agree with

the first reviewer we modified it to be “success rate curve” (line #320) and we cited of “Chung and Fabbri, 2003” (line #324).

Page 13 Line 387 The sentence is not clear. We already removed the sentence from the manuscript.

Page 13 Line 389 “The ranges of the prediction factors are good indicator to their effect”. This is not straightforward, be more descriptive. We modified the sentence (lines #418-423).

Page 13 Line 403 Substitute “withheld of” with “excluded from”. We substitute “withheld of” to “excluded from” (line #436).

Page 13 Line 407 Substitute “of” with “controlling the” We implemented that (line #440).

Page 13 Line 408 Remove “This means that” because this is implicit in the definition of odd ratio. We removed it.

Page 13 Line 415 Substitute “distribution of the LSI of” with “susceptibility zonations obtained using ” We did that (line #449).

Page 13 Line 417 Substitute “that their spatial distributions are similar” with “a similar spatial distribution”. We did that (line #450).

Page 14 Line 420 The sentence is not clear, please rephrase. We thank the first reviewer for this comment; we clarified the sentence (line #453).

Page 14 Line 422 Substitute “with each other” with “with other susceptibility models” We did that (lines #455-456).

Page 14 Line 426 Substitute “from GIS to a statistical software program” with “from GIS standard formats to the format required by the statistical software” We did that (line #460).

Page 14 Line 428 Substitute “forme.” with “form.” We implemented that (line #462).

Page 14 Line 436 In the paper the term “ROC curves” are wrongly used to refer to success rate curves. We agree with the first reviewer; we used the correct term, which is “Success Rate Curve (SRC)” in the whole manuscript (e.g. lines #13, 320, 321, 502. . .etc.).

Page 14 Line 438 Here and after substitute the terms “yield” with other terms. We implemented that (lines #469 and 472).

Page 14 Line 445 Again here the term validation is probably used to refer to the evaluation of the model skill performances. Please also refer to the comment on section 3.5. As we said before, we substitute “validation” with “prediction skill” for the whole manuscript (e.g. line # 317, 318, 324. . .etc.).

Page 14 Line 458 Substitute “that tested” with “tested” We implemented that (line #512).

Page 14 Line 474 This conclusion is a bit weak, remember that curvature can be calculated also considering different and greater kernel sizes. We agree with the first reviewer, we removed this conclusion.

Page 15 Line 480 Substitute “as the factor of” with “as significant factor to explain”. Moreover in the rest of the sentence be more descriptive. We Substituted “as the factor of” with “as a significant factor to explain”, and modified the sentence (line #543).

Page 16 Line 497 See previous comment on the topographical position index. We thank the first reviewer for this information, we modified that by removing “for the first time” from the sentence.

Page 16 Line 500 See previous comment on curvature. We removed this sentence from conclusions.

Page 16 Line 504 Substitute “to one other” with “one to each other”. We modified the sentence and we used “of each other” (line # 592).

Page 16 Line 509 See previous comments on validation. We used “prediction skill” term instead of “validation” (line #597).

FIGURE

Fig 1 Use “return period” in place of “of the Imbricated Zone” in the legend The geological term of “Imbricated Zone” is used by many publications such as (1) Jassim, S. Z. and Goff, J. C.: Geology of Iraq, Dolin, Brno, Czech Republic, 2006; (2) Fouad, S.F., 2010a. Tectonic Map of Iraq, scale 1:1,000,000, third ed. GEOSURV, Baghdad, Iraq; and (3) Sissakian, V. K.: Geological evolution of the Iraqi Mesopotamia Foredeep, inner platform and near surroundings of the Arabian Plate, Journal of Asian Earth Sciences, 2012. Therefore, we prefer to use “Imbricated Zone” term as the abovementioned authors stated.

Fig 3 Pictures do not allow to verify the real landslide type. Try to use different or more descriptive pictures. The graphical scale here are not useful, please try to use these to indicate some of the landslide characteristics (e.g. width, length, etc). We thank the first reviewer for this comment; we used the pictures, which are more descriptive. Moreover, we added the width and the length of the landslides instead of picture scale.

Fig 4 Use another color scale in maps in Figure F to highlight better or the curvature variation in the study area. We did that and we moved the figure to be Appendix (Appendix CF).

Fig 6 Is the figure A portraying TWI? It seems just a shaded relief of the study area. Please check. We thank the first reviewer for this comment; The TWI map was missing and we plotted again, and we moved the figure to be Appendix (Appendix EA).

Fig 7 What are the “prediction factors estimation ranges”? We meant, “the ranges of the prediction factor estimation weights”, and we stated that in the caption of the figure (figure 4).

Fig 9 A is not a ROC curve plot but a success rate curve plot We agree with the first

reviewer; we used “SRC plot” term instead of “ROC curve” (Figure 6A).

FIGURE CAPTIONS

Fig 1 Use “the Imbricated Zone” in place of “of the Imbricated Zone”. We implemented that.

Fig 3 Please use a standard term for the classification of “slumps” (e.g. Cruden & Varnes classification). We thank the first reviewer for this comment; we used the standard terms of (Cruden & Varnes classification).

Fig 8 What “based on different combinations models” means here? We removed this sentence from the caption of the figure (figure 5).

Fig 9 Move “Bar graph showing” after “(B)”. The plot in A is not a ROC curve plot but a success rate curve plot. We agree with the first reviewer; we moved “Bar graph showing” to be after “(B)” and we put “SRC plot” instead of “ROC curve” (Figure 6).

TABLES APPENDIX A

Number both table and modify their references in the text. We did that but we moved both to be as Appendix (Table A and B).

General reply to the first reviewer (3-C414-2015)

The authors should check the grammar and tenses. The tense keeps changing as the paper progresses and it would be good to be consistent and stick to one tense. We agree with the second reviewer, we improved English form (highlighted in magenta color).

A huge part of the paper goes into the explanation of slope, aspect, curvature etc. This is unnecessary and does not add any value to the paper. We agree with the second reviewer, we removed the explanation of the common factors such as slope, aspect, curvature, plain curvature and profile curvature.

The section on model validation is not well written. It has been specified that the dataset was split between training and validation dataset but this was not emphasized in the validation section. It should be made clear if the validation only involved the training dataset or only the validation dataset or both. If the validation only involves the training dataset then it cannot be termed as validation. At present the whole validation section is not clear and it appears that a success rate curve has been made. We thank the second reviewer for this comment. In the section 3.5 (lines #317-351), we emphasized that validation dataset was used to test the prediction skill of the models. In addition, we clarified and modified this section and used the term "prediction skill" instead of "validation" as the first reviewer asked (e.g. line # 317, 318, 324. . .etc.).

Model uncertainty, a very integral part of model calibration and validation, has not been assessed and it might be interesting to know if the differences in the results are purely because of model uncertainties. We thank the second reviewer for the suggestion; we tested the uncertainty associated to the susceptibility models. Two type of uncertainty were tested (1) Landslide susceptibility model error (Figure 7) and (2) Sensitivity analysis (Figure 8). Moreover, the method and outcome of these two uncertainty types were stated in lines # 339-351 and 489-505, respectively.

Comments and suggestions for the author

Title Substitute "Landslide susceptibility mapping in Mawat area" to "Landslide susceptibility mapping in the Mawat area" We implemented that in the title, and we changed the title.

Page 1790 Line 26: Grammatical error. Please rephrase. We put "Moreover, the landslide investigations are categorized into three main groups" instead of "Moreover, the landslide investigation can categorized into three main groups" (lines #23-24).

Page 1792 Line 12: Remove "in this area". We did that.

Page 1792 Line 22: Substitute "without any consideration of time the occurrences" to

"without any consideration of time of occurrences". We modified the phrase (line #70).

Page 1794 Line 23: Please rephrase. We rephrased the sentence (lines #123-128).

Page 1795 Line 5: Please add some more information about the characteristics of landslides which have been studied. We added more information about the characteristics of landslides, which have been studied (lines #118-122)

Page 1796 Line 4 to 10: The whole paragraph changes tenses. Please be consistent. We agree with the second reviewer, we modified the paragraph (lines #154-157).

Page 1797 Line 4: This is not a good definition of aspect. As the second reviewer asked in the previous command, we remove this definition from the manuscript.

Page 1797 Line7: The definition of curvature is not satisfactory. As the second reviewer asked in the previous command, we remove this definition from the manuscript.

Page 1797 Line 24: This is not 'HI'. It should be 'TPI'. We thank the second reviewer for this comment; we corrected the Equation (1) and (2) because it was inverted (Equation #1 and 2).

Page 1797 Line 26: This is not correct. TPI has been used in many papers e.g. 1. VORPAHL, P., ELSENBEER, H., MAERKER, M. & SCHROEDER, B. (2012) How can statistical models help to determine driving factors of landslides? Ecological Modelling, 239, 27-39. 2. COSTANZO, D., ROTIGLIANO, E., IRIGARAY, C., JIMENEZ-PERALVAREZ, J. D. & CHACON, J. (2012) Factors selection in landslide susceptibility modeling on large scale following the GIS matrix method: application to the river Beiro basin (Spain). Natural Hazards and Earth System Sciences, 12(2), 327-340. 3. MOHAMMADY, M., POURGHASEMI, H. R., & PRADHAN, B. (2012). Landslide susceptibility mapping at Golestan Province, Iran: a comparison between frequency ratio, Dempster–Shafer, and weights-of- evidence models. Journal of Asian Earth Sciences, 61, 221-236. We thank the second reviewer for this information, we modified that by removing "for the first time" from the sentence, and we cited the suggested citations

(lines #196).

Page 1804 Line 1: Is the LSI rank for the training dataset or validation dataset? We calculated the LS rank by using training dataset. However, the validation datasets were used in the y-axis (lines 323-324).

Page 1805 Line 8: Substitute “Only curvature, plan” to “Since curvature, plan”. We did that (line #365)

Page 1805 Line 24: Substitute “smaller 0.22” to “smaller than 0.22”. We thank the second reviewer for this comment; we implemented that (line #379)

Page 1806 Line 7: Why are the tables numbered as Table 1 and Table A1. They should be renumbered and referenced in the paper accordingly. We thank the second reviewer for this comment; we renumbered the tables in the paper accordingly as appendices (Appendix A and B).

Page 1806 Line 20-25: Please rephrase. The section is difficult to read. We thank the second reviewer for this comment; we rephrased this section (lines #401-407).

Page 1808 Line 1: Substitute “withheld of” to “withheld from”. We substitute “withheld of” to “excluded from” (line #436).

Page 1808 Line 2: No full stop needed. Both sentences can be merged. We modified both sentences (lines #435-438).

Page 1808 Line 21: “GIS based techniques” is very vague and too general. Please be more specific. We thank the second reviewer for this comment; we already explained the GIS techniques, which used (lines #66-67).

Page 1810 Line 17: Substitute “noted that number” to “noted that the number”. We implemented that (line #518).

Page 1810 Line 23: Substitute “significant impact for landsliding” to “significant impact on landsliding”. We implemented that (line #530-531).

Page 1810 Line 28: Substitute “Thus it can reflects slope” to “Thus it can reflect slope”. We already remove this sentence, as the first reviewer mentioned.

Page 1811 Line 23: Substitute “most of them were” to “most of which were”. We modified the sentence (line # 585).

Page 1812 Line 8: Substitute “simple and easier” to “simple and easy”. We did that (lines # 458).

Figure

Figure 1: The patter used is too dense making it difficult to read the text. Consider changing the shading pattern. We thank the second reviewer for this comment; we modified the figure (Figure 1).

Figure 2: Add ± 1 Standard deviation on precipitation bars. We thank the second reviewer for this comment; we added ± 1 Standard deviation on precipitation bars (Figure 2).

Figure 3: The scales on the snaps area incorrect. The snaps have not been taken at nadir and the scale changes from one point of the snap to another. If you want to put the scale, please make sure which point on the snap represents that scale. We thank the second reviewer for this comment; we used the pictures, which are more descriptive. Moreover, we added the width and the length of the landslides instead of picture scale.

Figure 4: The texts in legends are too small and difficult to read. We thank the second reviewer for this comment; we clarified the legend to be readable (Appendix C).

Figure 6: The texts in legends are too small and difficult to read. 6(a) looks like a hillshade map, instead of TWI map. We thank the second reviewer for this comment; we clarified the legend to be readable (Appendix C). Moreover, The TWI map was missing and we plotted again (Appendix EA).

Figure 8: Are these results from ‘combination models’? Please correct this. We thank the second reviewer for this comment; we modified the caption of figure 5.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/3/C1347/2015/nhessd-3-C1347-2015-supplement.pdf

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 1789, 2015.