Review comments and responses

Reviewer 1

Over view

Hazard assessment modeling and software development of earthquake-triggered landslides in the Sichuan-Yunnan area, China by Shao et al. presents a rapid landslide mapping tool - Mat.LShazard based on logistic regression model, which they successfully applied to six earthquake affected sites in Sichuan-Yunnan region. The manuscript is well written and the toolbox may have wide applicability in future hazard scenarios. However, there are some concerns that need to be addressed.

Comments

1. Firstly, the stage 1, stage 2, and stage 3 as discussed in this paper is subjective. Obtaining remote sensing images within 12 hours after the quake and detailed images 3 days after the event is depends on many factors. At this point, it is better to define them as stage 2 and stage 3 only. May be termed as – stage 1 immediately after the event, stage 2 = hours to a few days (e.g., Planet), and stage 3 = few days to weeks (e.g., Planet, Sentinel 2, Landsat 8/9).

Authors' response: Yes, we have redefined the second and third phases, as you suggested.

2. Description on stage 1: Authors wrote - More detailed theory and calculation procedures can be found in (Xu et al., 2019). Xu et al 2019 is a paper written in Chinese Language. Hence describing more on the procedure of stage 1 is important for global readers. What are the inputs in stage 1?

Authors' response: Yes, we added the details of independent variables for the Xu_{2019} model in the text (line 265-270). Meanwhile, we added the detailed description of the Xu_{2019} model in the supplementary materials, including the selection of earthquake-induced landslide inventories, the input of influence factors and calculation procedures of the model.

3. Difference in stage 2 and stage 3: As far as I understand, the difference between these two stages is incorporation of more accurate training samples of landslides. Is it so? I believe the conditioning factors remains the same. This has to be explained clearly.

Authors' response: Yes. For the second and third stages, we chose the same influencing factors as the input in the first stage, so that we can easily compare the regression coefficient changes of different influencing factors in different stages, and thus explain the relationship between each influencing factor and the landslide occurrence. Relevant explanations have been added in section 3.21 (line 277-281).

4. How Mat.LShazard model is different from USGS models – Godt 2008 and Nowicki Jessee et al 2018 ?.

Authors' response：The Godt 2008 and Nowicki Jessee et al 2018 models are near-real-time assessment models of coseismic landslides. Among them, the Godt 2008 model adopts the physically-based Newmark displacement method and has been widely used for quickly assessing *earthquake-induced landslides in the world. However, it should be mentioned that emergency hazard assessments based on the Newmark model require multiple parameters, including terrain, geotechnical mechanics, groundwater and ground motion, etc. There are numerous uncertainties in both these parameters themselves and the process of obtaining these parameters (Bojadjieva et al., 2018; Wang et al., 2015). To obtain more precise predicted displacement, the Newmark method needs accurate and complete physical and mechanical property information of rocks and ground motion parameters (Dreyfus et al., 2013), which is often challenging. Therefore, the accuracy of regional prediction results based on the Newmark model is relatively low, which cannot meet the needs of emergency assessment at present. Based on 23 global landslide inventories, Nowicki Jessee et al. (2018) established a new global landslide evaluation model using the data-driven method. However, the model is affected by the input samples of seismic landslide samples, and the applicability and accuracy of the model in the Sichuan Yunnan region are reduced.*

The Mat. LSHazard model is the tool for earthquake landslide hazard assessment, which can be applied to three different scenarios in the Sichuan Yunnan region. The model used in the first stage is a near-real-time assessmnet model (Xu2019 model) based on 9 seismic landslide databases near the Sichuan Yunnan region and shows a better applicability performance in the Sichuan Yunnan region, compared with the Nowicki Jessee et al 2018 model. Otherwise, the Nowicki Jessee 2018 model uses the same ratio of sliding samples as that of non-sliding samples to train the LR model. This sampling method artificially exaggerates the proportion of sliding samples in the study area, and thus the assessment results only consider the relative hazard level but do not represent the real occurrence probability of landslides. Therefore, the Xu_{2019} *model combines the bayesian probability method with the LR model, realizing the establishment of a new generation of coseismic landslide hazard model, which can give landslide occurrence probability instead of relative hazard level. Meanwhile, we have supplemented the corresponding programs for the second and third stages to ensure that the Mat.LSHazard model can meet the various needs of disaster prevention and reduction in different stages after the major earthquake.*

Bojadjieva, J., Sheshov, V., Christophe, B., 2018. Hazard and risk assessment of earthquake-induced landslides—case study. Landslides, 15, 161-171.

Wang, T., Wu, S., Shi, J., XIn, P., 2015. Concepts and mechanical assessment method for seismic landslide hazard: A review. Journal of Engineering Geology, 23, 93—104.

Dreyfus, D.K., Rathje, E.M., Jibson, R.W., 2013. The influence of different simplified sliding-block models and input parameters on regional predictions of seismic landslides triggered by the Northridge earthquake. Engineering Geology, 163, 41-54.

Nowicki Jessee, M.A. et al., 2018. A global empirical model for near-real-time assessment of seismicallyinduced landslides. Journal of Geophysical Research: Earth Surface, 123, 1835-1859.

Xu, C., Xu, X., Zhou, B., Shen, L., 2019. Probability of coseimic landslides: A new generation of earthquake-triggered landslide hazard model. Journal of Engineering Geology, 27, 1122.

5. Line 387 – How is this random selection achieved? It is not clear that in stage 2, for the final map, whether the study used all the 50 combinations for obtaining the mean probability distribution. If so, the accuracy is obviously close to stage 3. Instead, the study could have used random 6 (or X) combinations and their mean to get the probability distribution map. We could naturally expect high accuracy in third stage as all the landslide are used in training.

Authors' response: Yes. To avoid the sampling randomness, we chose 70% of all samples at random and independently repeated 50 times to construct the LR model based on partial landslide data available in the the meizoseismal area. 50 separate experiments yielded 50 modelling results. Fig. 7 and 8 show the mean probability prediction results of 50 models in the second and third stages of 6 earthquake events respectively. For the third stage, we also employed the same random sampling method, and each time we extracted 70% of all samples (complete landslide data in the entire earthquake area) to generate 50 model results. The only difference is that the samples used for model training in the second stage and the third stage are different. Because the training samples used in the third stage are the complete landslide data of the entire quake region, the accuracy of the evaluation results in the third stage is higher. Relevant descriptions have been added in Section 4.2 (line 410-413 and line 429-434).

6. Since stage 3 involve mapping all landslides, then the applicability of the model for other study areas is limited. I would like to see how this model works for a validation site.

Authors' response: Yes. In this study, we randomly selected 70% of the total samples for model training, and the remaining 30% were used for model validation; this step was repeated for a total of 50 times. In the third stage, it is assumed that we obtained the coseismic landslide data of the whole quake area based on the pre- and post-quake images, and then carried out the earthquake-induced landslide hazard assessment based on the complete landslide inventory. The assessment result can serve for the identification of the potential landslide high-hazard areas and the post-disaster restoration and infrastructure reconstruction in earthquake disaster areas. Meanwhile, since the model was trained by coseismic landslide data in this region, it is theoretically only applicable to this region.

7. Line 446 – We chose 4 independent variable…. Why 4 ? what about remaining 9?

Authors' response: Yes. Due to limited space, we only showed four independent variables, which have more obvious impact on the landslide occurrence in the text. Therefore, in the supplementary materials, we have added the regression coefficients of all continuous variables (Fig.1s).

8. What threshold is used for calculating Ap in this study?

Authors' response: In this study, based on previous studies, we explored a new sampling method (Shao et al 2020). Based on this method， the prediction results represent the real landslide probability. In other words, we correlated the resulting probability with spatial extent (e.g., areas labeled 5% probability of landsliding contain about 5% landslides by area). Therefore, the probability value of each grid multiplied by the grid area represents the predicted landslide area in each grid. The predicted landslide area in the study area can be obtained by the superposition of all grids (Allstadt, et al 2018). For all model outputs, we computed and obtained the predicted landslide area (Ap) as a metric to summarize the total hazard estimated by a given model for a given earthquake with a single number. The predicted landslide area (Ap) was computed by

$$A_p = \sum_{i=1}^{m} \sum_{j=1}^{n} p_{i,j} A \qquad (5)$$

where $p_{i,j}$ is the probability of a landslide at pixel i, j; m is the number of rows; n is the number of columns; A is the pixel/cell area (constant).

Allstadt, K.E. et al., 2018. Improving Near-Real-Time Coseismic Landslide Models: Lessons Learned from the 2016 Kaikōura, New Zealand, Earthquake. Bulletin of the Seismological Society

of America, 108, 1649-1664.
Shao, X., Ma, S., Xu, C., Zhou, Q., 2020. Effects of sampling intensity and non-slide/slide sample ratio on the occurrence probability of coseismic landslides. Geomorphology, 363, 107222.

Minor comments

9. Line 28 -29 is confusing- rephrase to get a better reading

Authors' response: Yes. We have rewritten this sentence.

10.Fig 5. Is this the result of stage 1? . if so mention it in the caption.

Authors' response: Yes. We have revised it.

11. Same for Fig 8. Is this the result of stage 2 or 3?

Authors' response: Yes. We have revised it.

12. Apart from the graphs, there could also been a table for accuracy matrices.

Authors' response: Yes. We have added the corresponding tables about the accuracy matrices in supplementary materials.