Response to Decision Letter

Dear Dr. Paolo Tarolli and referee,

We are very pleased to learn from your letter about revision for our manuscript which entitled *"Dangerous degree forecast of soil and water loss on highway slopes in mountainous areas using RUSLE model".*

We greatly appreciate reviewer's thoughtful suggestions concerning improvement to our paper. These comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches.

Thank you for your consideration!

Sincerely yours,

*Corresponding Author: Shi Qi

P.S.

Response to review's comments for nhess-2017-406-RC2

Reviewer's #2 comments:

Comment 1: Highway is booming in China in recent twenty years. Hence how to control soil erosion from the subgrade slope is an important issue of the road safety. From this point, the topic is valuable.

Response 1: Thank you for your careful reading of our manuscript. Thank you for the affirmation and support of this topic!

Comment 2: The manuscript is also readable although still many language errors exist. Nevertheless, the structure of the paper is poor.

Response 2: We are sorry for many language mistakes. Furthermore, we polished the manuscript with a professional assistance in writing, conscientiously. We hope that the new manuscript can meet your request. The revised part of the manuscript was marked in red, details in the manuscript.

Comment 3: Instead of a research paper, the manuscript looks like a scientific report. Too many original data are shown in the manuscript but short of in-depth discussions. I strongly suggest the authors rewrite the manuscript.

Response 3: Thank you for your valuable and thoughtful comments. According to your helpful advice, we have made a detailed revision and adjustment of the manuscript,

the revised part of the manuscript was marked in red, details in the manuscript.

Comment 4: Abstract. Lines 29-30: The word "show" should be replaced with the word "shows". There are many grammar errors throughout the manuscript. I think the paper may be polished by a soil scientist whose native language is English.

Response 4: Thank you for your patience and careful work! we have made correction according to your comments. Details are in following paragraph and manuscript.

Many high and steep slopes are formed by special topographic and geomorphic types and mining activities during the construction of mountain expressways. Severe soil erosion may occur under heavy rainfall conditions. Therefore, predicting soil and water loss on highway slopes is important in protecting infrastructure and human life. This work studies Xinhe Expressway, which is in the southern edge of Yunnan–Guizhou Plateau, as the research area. The revised universal soil loss equation is selected as the prediction model of the soil and water loss on the slopes. Moreover, geographic information system, remote sensing technology, field survey, runoff plot observation testing, cluster analysis, and cokriging are adopted. The partition of the prediction units of the soil and water loss on the expressway slope in the mountain area and the spatial distribution model of the linear highway rainfall are studied. In view of the particularity of the expressway slope in the mountain area, the model parameter factor is modified and the risk of soil and water loss along the mountain expressway is simulated and predicted under 20- and 1-year rainfall return periods. The results are as follows. (1) Considering natural watershed as the prediction unit of slope soil erosion can represent the actual situation of the soil and water loss of each slope. The spatial location of the soil erosion unit is realized. (2) An analysis of the actual observation data shows that the overall average absolute error of the monitoring area is 33.24 $t \cdot km^{-2} \cdot a^{-1}$, the overall average relative error is 33.96%, and the overall root mean square error is between 20.95 and 65.64, all of which are within acceptable limits. The Nash efficiency coefficient is 0.67, which shows that the prediction accuracy of the model satisfies the requirements. (3) Under the condition of 1-year rainfall, we find through risk classification that the percentage of prediction units with no risk of erosion is 78%. Results show that soil erosion risk is low and therefore does not affect road traffic safety. Under the 20-year rainfall condition, the percentage of units with high risk and extremely high risk is 7.11% and mainly distributed on the K109+500–K110+500 and K133–K139+800 sections. The prediction results can help adjust the layout of the water and soil conservation measures in these units.

Comment 5: Lines 28-30: Is the error of the erosion rate per year? I think the unit may be $t \cdot km^{-2} \cdot a^{-1}$. So are the units of the erosion rates appear through the manuscript.

Response 5: Thank you for your comments! We have followed your advice to adjust it. Details are in following paragraph and manuscript.

An analysis of the actual observation data shows that the overall average absolute error of the monitoring area is 33.24 $t \cdot km^{-2} \cdot a^{-1}$, the overall average relative error is 33.96%, and the overall root mean square error is between 20.95 and 65.64, all of which are within acceptable limits.

Comment 6: Lines 30-31: The unit of the root mean square error of the soil loss is same to the unit of soil loss. Here the unit is $t \cdot km^{-2} \cdot a^{-1}$

Response 6: Thank you for your patience and careful work! We have made correction according to your comments. Details are in the manuscript.

Comment 7: Lines 33-37: You said "the percentage of prediction units with no risk of erosion is 78% and that with mild soil erosion risk is 15.92%". Do you mean the high and extremely high risk is 1-78%-15.92%=6%? If my deduction is right, I think no large difference exists between this risk and that described in line 37, 7.11%.

Response 7: For the first question, we agreed your comment after all the authors discuss.

For the second question, we think this is under different rainstorm frequencies. They are: Under the condition of 1-year rainfall, we find through risk classification that the percentage of prediction units with no risk of erosion is 78%. Results show that soil erosion risk is low and therefore does not affect road traffic safety. Under the 20-year rainfall condition, the percentage of units with high risk and extremely high risk is 7.11% and mainly distributed on the K109+500–K110+500 and K133–K139+800 sections.

Comment 8: Introduction. Lines 60-61: "In the next 20-30 years, expressways in China will measure more than 40 thousand km". However I find in the network that "since 2016, the total length of the highway in China is about 131 thousand km". I do not know which length is correct?

Response 8: Thank you for your patience and careful work! We have made correction and modification this sentence by consulting the reference, the revised sentence and reference are as follows:

At present, China's highway industry is still in a period of rapid development. By the end of 2014, the total mileages of highway network exceeds 4,400,000 kilometers, and the expressway's mileage is 112,000 kilometers (Zhou et al., 2016). According to statistics, with the development of highway construction in China, slope areas reach 200–300 million m^2 each year. In the next 20–30 years, expressways in China will measure more than 40,000 km. For every kilometer of a highway, the corresponding bare slope area formed measures 50,000–70,000 m^2. The annual amount of soil erosion is 9,000 g/m^2, which causes 450 t of soil loss every year (Chen 2010).

References:

Yuan, C., Yu, Q. H., You, Y. H., Guo, L.: Deformation mechanism of an expressway embankment in warm and high ice content permafrost regions. Applied Thermal Engineering 121: 1032-1039, 2017.

Mori, A., Subramanian, S. S., Ishikawa, T., Komatsu, M. A Case Study of a Cut Slope Failure Influenced by Snowmelt and Rainfall. Procedia Engineering, 189: 533-538, 2017.

Zhou, R. G., Zhong, L. D., Zhao, N. L., Fang, J., Chai, H., Jian, Z., Wei, L., Li. B.: The Development and Practice of China Highway Capacity Research. Transportation Research Procedia, 15: 14-25, 2016.

Kateb, H. E., Zhang, H. F., Zhang, P. C., Mosandl, R. Soil erosion and surface runoff on different vegetation covers and slope gradients: A field experiment in Southern Shaanxi Province, China. Catena, 105(5): 1-10, 2013.

Comment 9: Line 131: “... the main type of soil erosion in the study area was gully erosion”. Could USLE or RUSLE be applied in the gully erosion?

Response 9: Thank you for your comments! According to your comments, we explained it. Details are in following paragraph.

Some researchers have adjusted the model parameters of the RUSLE model based on the actual situation in each region, making this model applicable to gully erosion.

Comment 10: Lines 62-63: I am lost! Might you kindly let me you the area attacked by soil erosion in this sentence?

Response 10: Thank you for your comments! According to your comments, we explained it. Details are in following paragraph.

Chen’s (2010) research is based on data collected during the expressway construction period, so as to estimate the area of the bare slope and the amount of soil erosion that can form in the next 20-30 years. It does not mean the amount of soil erosion in one place.

Comment 11: Line 68: The word “affect” should be “affects” or “influences”.

Response 11: Thank you for your careful reading of our manuscript. we have made correction according to the your comments. Details are in following paragraph and MS.

Soil erosion on subgrade side slopes affects not only soil and water loss along the highway but also road operation safety (Gong and Yang 2016; Jiang et al., 2017).

Comment 12: Line 78: What’s the meaning of the following sentence: “...have explored the process of using the RUSLE model”?

Response 12: Thank you for your comments! According to your comments, we adjusted it. Details are in following paragraph and manuscript.

In addition, many scholars have explored the process of using RUSLE models and combined research objects to correct the parameter values in these models

Comment 13: Lines 81-82: I am lost.

Response 13: Thank you for your comments! According to your comments, we adjusted it. Details are in following paragraph and manuscript.

Tresch et al. (1995) believed that the slope length/slope steepness factor *LS* is one of the main factors for soil erosion modeling within the RUSLE environment. Various steepness factors (*S*) exist for the most used soil erosion modeling environment and significantly influence calculated erosion values.

Comment 14: Line 85: 20%-90% should be revised as follows: 20-90%.

Response 14: Thank you for your patience and careful work. We are grateful to you for pointing out this comment. We have followed your advise to adjusted it. Details are in following paragraph and MS.

Eighteen plot measurements on transects along slopes ranging from 20–90% in steepness were used in this study to qualitatively assess the most suitable *S* factors for steep subalpine slopes. Results showed that a first selection of an *S* factor was possible for slopes above the critical 25% steepness (Tresch et al., 1995).

Comment 15: Lines 125-126: I cannot understand.

Response 15: Thank you for your comments! According to your comments, we adjusted it. Details are in following paragraph and manuscript.

However, the accumulation degree of soil and water loss in highways cannot satisfy the requirements of model development (Xu et al., 2009; Bakr et al., 2012). To date, no mature model of soil erosion in highways is available.

Comment 16: Line 141: “According to studies at home and abroad”. Please remember you are writing a paper for the international journal instead of a scientific report in Chinese!

Response 16: Thank you very much for your reminding and advice! We have followed your advice to adjust it. Details are in following paragraph and MS.

According to the literature, the study of soil and water loss in highways has the following problems.

Comment 17: Line 158: “In this study,” may be added in front of the sentence “A suitable...”

Response 17: We greatly appreciate your valuable suggestion concerning improvement to this paper. We have followed your advice to adjust it. Details are in following paragraph and MS.

In this study, a suitable prediction model of soil and water loss is established, the parameters of the model are revised, and the risk of soil and water loss under different rainfall scenarios is simulated and predicted.

Comment 18: Lines 161-162: I am lost.

Response 18: Thank you for your comments! According to your comments, we adjusted it. Details are in following paragraph and manuscript.

This study scientifically not only predicts the amount of soil erosion caused by highway construction in mountain areas for the rational layout of facilities, which reduces damage to the original topography and effectively prevents and controls new soil erosion, but also provides scientific and technical bases and reference methods.

Comment 19: Study area. Line 193: Figure 1 may be merged to Figure 4 in page 11.

Response 19: Thank you for your comments! According to your comments, we explained it, details are in following paragraph.

Figure 1 refers to the overview of the study region, figure 4 refers to the division results of prediction units. After all the authors discuss, we believed that these two graphs express independent content, and the content expressed in Figure 4 is not closely related to chapter 2 (Study area).

Comment 20: Materials and method. All of the subtitle of the part, including 3.1, 3.1.1-3.3.4, and 3.2, may be erased. Attention please, some of the subtitles in the manuscript are wrong.

Response 20: We are sorry for this mistake. We have carefully corrected it throughout the manuscript according to your comment. Details are in the paragraph.

Comment 21: Results and analysis. From page 9 to page 22: The part looks like a scientific report instead of a research paper. Except the original experimental data, hardly any in-depth discussion exists.

Response 21: Thank you for your instructive suggestions. According to your helpful advice, we have rewritten these parts. Details are in the paragraph. Thank you again!

Comment 22: Page 23: The calculated results have not been compared with the results described in other references. Also I do not know why the errors emerge.

Response 22: According to your comments, we explained it. Details are in following paragraph.

According to the literature, we found that the related research mainly focused on the estimation of soil erosion under the soil and water conservation measures of different types of slope protection. However, the research content of this paper is to use the RUSLE equation as the prediction model for soil and water loss on slopes with GIS technology as support in view of the characteristics of soil and water loss in mountain expressways. The soil erodibility factor (K), slope length factor (LS), and soil and water conservation measure factor (P) are revised to improve the method of dividing slope units. In determining the predictive parameters of the model, the R factor is obtained by spatial interpolation.

The use of this technique addresses the shortage of rainfall data in mountain areas, the difficulty of representing the rainfall data of an entire expressway with those from a single meteorological station, and the uneven spatial distribution and strong heterogeneity of rainfall in mountain areas. In this study, a suitable prediction model of soil and water loss is established, the parameters of the model are revised, and the risk of soil and water loss under different rainfall scenarios is simulated and predicted.

Comment 23: Some of other problems are shown as follows: Where is the line number?

Response 23: We are sorry for this mistake. We have carefully corrected it throughout the manuscript according to your comment. Details are in the paragraph.

Comment 24: Segment 4.1: The segment is a method, and it may be simplified and removed to Part 3 Materials and method.

Response 24: Thank you for your instructive suggestions. According to your comments, we adjusted it. Details are in the manuscript.

Comment 25: Segment 4.2.5 in page 21: Why were the landform factors calculated according to the natural slopes (4.2.3) and the artificial slope (4.2.4), but was the vegetation cover calculated only in one situation (4.2.5)?

Response 25: Thank you for your comments! According to your comments, we explained it. Details are in following paragraph.

The C-factor after topography is an important factor that controls soil loss risk. In the RUSLE model, the C-factor has been used to reflect the effects of vegetation cover and management practices on the soil erosion rate ((Vander-Knijff et al., 2000; Prasannakumar et al., 2011; Alkharabsheh et al., 2013). It is defined as the loss ratio of soils from land cropped under specific conditions to the corresponding loss from clean-tilled and continuous fallow (Wischmeier and Smith, 1978). Due to the variety of land cover patterns with severe spatial and temporal variation, mainly in the watershed scale, data sets from satellite remote sensing were used to assess the C-factor (Vander-Knijff et al., 2000; Li et al., 2010; Chen et al., 2011; Alexakis et al., 2013). The algorithm used in this paper is a method to calculate the C factor proposed by Cai et al. (2000), it is related to vegetation and crop coverage. The formula is shown as (11). The algorithm for calculating f is referred to Tan et al (2005). The formula is shown as (12):

$$C = \begin{cases} 1 & 0 \le f < 0.1\% \\ 0.6508 - 0.3436 \times lg(f) & 0.1\% \le f < 78.3\% \\ 0 & f \ge 78.3\% \end{cases} \quad (11)$$

$$f = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \quad (12)$$

In the formula: f is the vegetation coverage, NDVI is the normalized differential vegetation index, $NDVI_{max}$ and $NDVI_{min}$ are the minimum and maximum value of NDVI in the study region, respectively.

References:

Tan, B. X., Li, Z. Y., Wang, Y .H., Yu, P. T., Liu, L. B.: Estimation of Vegetation Coverage and Analysis of Soil Erosion Using Remote Sensing Data for Guishuihe Drainage Basin. Remote sensing technology and application. 20 (2): 215-220, 2005.

Cai, C. F., Ding, S. W., Shi, Z. H., Huang, L., Zhang, G. Y.: Study of Applying USLE and Geographical Information System IDRISI to Predict Soil Erosion in Small Watershed. Journal of Soil and Water Conservation. 14(2): 19-24, 2000.

Vander-Knijff, J.M., Jones, R.J.A., Montanarella, L.: Soil Erosion Risk Assessment in Europe EUR 19044 EN. Office for Official Publications of the European Communities, Luxembourg. 34, 2000.

Wischmeier, W.H., Smith, D.D.: Predicting rainfall erosion losses: a guide to conservation planning. In: USDA, Agriculture Handbook No. 537, Washington, DC, 1978.

Prasannakumar, R., Shiny, N., Geetha, H., Vijith, H.: Spatial prediction of soil erosion risk by remote sensing, GIS and RUSLE approach: a case study of Siruvani river watershed in Attapady valley, Kerala, India. Environmental Earth Science, 965-972, 2011.

Alkharabsheh, M.M., Alexandridis, T.K., Bilasb, G., Misopolinos, N.: Impact of land cover change on soil erosion hazard in northern Jordan using remote sensing and GIS. Four decades of progress in monitoring and modeling of processes in the soil-plant-atmosphere system: applications and challenges. Procedia Environmental Science, 19, 912-921, 2013.

Li, H., Chen, X. L., Kyoung, J. L., Cai, X. B., Myung S.: Assessment of soil erosion and sediment yield in Liao watershed, Jiangxi Province, China, using USLE, GIS, and RS. Journal of Earth Science 2 (6), 941-953, 2010

Alexakis, D., Diofantos, G., Hadjimitsis, A.: Integrated use of remote sensing, GIS and precipitation data for the assessment of soil erosion rate in the catchment area of “Yialias” in Cyprus. Atmospheric Research, 131, 108-124, 2013.

Chen, T., Niu, R. Q., Li, P. X., Zhang, L. P., Du, B.: Regional soil erosion risk mapping using RUSLE, GIS, and remote sensing: a case study in miyun watershed, north china. Environmental Earth Sciences, 63(3), 533-541, 2011.

Comment 26: Line 4 of page 28: “A cement box should be added in the soil a year”: Is this the only conservation practice we should adopt?

Response 26: Thank you for your comments! According to your comments, we explained it. Details are in following paragraph.

Some other conservation practices: The technology of mortar rubble retaining wall and retaining wall (slope); the technology of honeycomb mesh grass protection; the technology of hydraulic seeding grass protection.

Comment 27: References. Page 29: “Liu, X. Y.: Study on the slope stability and its rheological influence in Mountain highway. Central South University, 2013”: Is it a paper in Chinese journal or international journal, or an academic dissertation in Chinese?

Response 27: Thank you for your comments! According to your comments, we explained it. Details are in following paragraph.

This article is a graduation thesis in Chinese.

Comment 28: Page 30: “Bosco, C., De Rigo, D., Dewitte, O., Poesen, J., and...” should be removed forward as the second reference.

Response 28: Thank you for your careful reading of our manuscript. We have followed your advice to adjust it. Details are in the manuscript.

Comment 29: Page30: “Wang, H. J., Yang, Y., and Wang, W. J.: Prediction of Soil Loss Quantity...”: Is it a paper in Chinese journal?

Response 29: Thank you for your careful reading of our manuscript. we explained it. Details are in following paragraph.

This article is an academic dissertation in Chinese.