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 Revised Universal Soil Loss Equation 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.

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Response to review's comments for nhess-2017-406-Report 1

Reviewer's #1 comments

Comment 1: In page 23 of the Response to Decision Letter, you said "After careful checking, we think that the relevant parts of the manuscript is (are) independent of the RUSLE model. Therefore, it is incompatible with the core idea of this paragraph. So, we decided to delete this sentence for the sake of the accuracy of the manuscript." Nevertheless, the title of your paper is as follows: Dangerous degree forecast of …. USING RUSLE MODEL.

Response 1: Thank you for your patience and careful work! We have followed your advice to explain it. Details are in the following paragraph.

In this paper, the RUSLE model is used to predict the soil erosion of the expressway slope in mountainous area. But in the original manuscript, the study of Yang (2001) mentioned in the introduction was about gully erosion, so we decided to delete the following contents:

Yang (2001) investigated the behavior of soil erosion on the slope of a railway embankment

during construction by comparing artificial and natural rainfalls on the special Qinhuangdao-Shenyang line of passenger trains. The results showed that the main type of soil erosion in the study area was gully erosion, which caused more soil erosion than surface erosion did.

Comment 2: In depth discussions are still needed. Yes, you have added two paragraphs in the section Discussion. However, the second paragraph, lines 567-576 in page 27, is not a discussion. I think to put the paragraph in the end of the Section Introduction is the best.

Response 2: 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 manuscript.

In this study, we analyse the following characteristics of soil erosion to improve certain aspects expressway construction based on previous research: (1) We divide the highway slope into natural and artificial units and calculate the amount of soil loss from the slope surface to the pavement based on the slope surface catchment unit. Considering that this approach is in line with the actual situation, the findings can thus can be popularised. (2) Previous studies have shown that the spatial interpolation method of precipitation has been stagnant in the study of the spatial and temporal distribution of precipitation in mountain areas (Liu and Zhang, 2006). At the same time, the problem involves two aspects. From the timescale perspective, the characteristics of rainfall distribution and the influencing factors are not fully considered. From the spatial scale perspective, the spatial heterogeneity of the region is ignored. Many studies have limited the factors affecting precipitation to altitude factors, thereby leading to low interpolation accuracy (Zhao et al., 2011; Liu et al., 2010). Thus, we consider the spatial heterogeneity of linear engineering of the expressway. Then, the rainfall factor is spatially interpolated to compensate the following limitations: shortage of rainfall data of mountain areas; difficulty of representing the rainfall data of an entire expressway by using those data from a single meteorological station; and uneven spatial distribution and strong heterogeneity of rainfall in mountain areas (Li et al., 2017). (3) We modify the parameters of the artificial slope by actual survey, runoff plot observation and other methods, and the parameters of the artificial slope are corrected by referring to the form of the project and the utilised materials. In this study, we not only scientifically predict the amount of

soil erosion caused by highway construction in mountain areas but also provide a scientific basis for the prevention and control of soil erosion and the rational allocation of prevention and control measures. Moreover, the safe operation of highways and the virtuous cycle of the ecological environment should be ensured to promote the sustainable development of the local economy.

Reference:

Li, Y., Qi S., Cheng, B. H., Ma, J. M., Ma, C., Qiu, Y. D., Chen, Q. Y.: A Study on Factors of Space-time Distributions of Precipitation in Ailao Mountain Area and Comparison of Interpolation Methods. EARTH AND ENVIRONMENT, 45(6): 600-610 (in Chinese)

Liu, J. T., Zhang, J. B.: Interpolation analysis of the spatial distribution of precipitation in mountain area. Journal of Irrigation & Drainage, 25:34-38, 2006 (in Chinese)

Zhao, C. C., Ding, Y. J., Ye, B. S., Zhao, Q. D.: Spatial distribution of precipitation in Tianshan Mountains and its estimation. Advance in water science, 22:315-322, 2011 (in Chinese)

Liu, Z. Y., Zhang, X., Fang, R. H. Analysis of spatial interpolation methods to precipitation in Yulin based on DEM. Journal of Northwest A&F University (Nat. Sci. Ed.), 38:227-234, 2010 (in Chinese)

Comment 3: There are so many language errors in the latest version of the manuscript. For example, in lines 81-83, the word factor may be revised as factors, and the word influence may be revised as influences. In line 567, the word analysis may be revised as analyzes.

Response 3: We are grateful to the reviewer for pointing out these mistake. We have followed your advice to revise it. Details are in following paragraph and manuscript.

Line 81-83:

Tresch et al. (1995), in a study of Switzerland, argued that the slope length (*L*) or slope steepness factor (*S*) is one of the main factors of soil erosion prediction, and these parameters significantly influenced the erosion values calculated by RUSLE.

Line 567:

In this study, we analyse the following characteristics of soil erosion to improve certain aspects expressway construction based on previous research.

Comment 4: I am sorry in the latest manuscript I could not find what you said in the last page of the Response to Decision Letter, namely Technology of masonry retaining wall; (maybe comma is better here) Technology of honeycomb grid revetment protection...

Response 4: Thank you for your comments! We have followed your advice to revised it. Details are in following paragraph and manuscript.

We may consider slowing down the roadbed slope to keep the slope stable, and ecological slope protection technologies can be adopted. For example, the spraying and planting technology of bolt hanging net can be used to build a layer of planting matrix that can grow and develop on the weathered rock slope, as they can resist the porous and stable structure of the scouring. Technologies of masonry retaining wall and honeycomb grid revetment protection can also be used. Various technologies can be adopted for the purpose of preventing and controlling soil erosion, and they can beautify the landscape environment of the road area whilst ensuring road traffic safety.

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.

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Response to review's comments for nhess-2017-406-Report 2

Reviewer's #2 comments:

Comment 1: General: This article needs a final read by a proofreader for the English language. There are numerous small errors with use of singulars and plurals and general phrasing.

Response 1: Thank you for your patience and careful work! We have revised the manuscript again, we hope to meet your requirements. Details are in the manuscript.

Comment 2: Line 19: Geographic information system correct to 'systems' (plural), and the same for field survey (should be plural).

Response 2: Thank you for your comments. We have followed your advice to revise it. Details are in following paragraph and manuscript.

Moreover, geographic information systems, remote sensing technology, field surveys, runoff plot observation testing, cluster analysis and co-kriging calculations are adopted.

Comment 3: Line 29. Unclear what the unit 'a' is. I am guessing that t is tonnes but this is also not immediately clear.

Response 3: Thank you for your comments! We have followed your advice to explain it. Details are in the following paragraph.

'a' means 'anniversary'.

Comment 4: Line 30 should RMSE have the same units as the absolute error?

Response 4: Thank you for your comments! We have followed your advice to explain it. Details are in the following paragraph.

Absolute error is the absolute magnitude of the deviation of the measured value from the true value, so its unit is the same as that of the measured value.

The root mean square error is the deviation between the observed value and its true value, or the observed value and its simulated value. It is dimensionless.

Comment 5: Line 36. It will be unclear to the reader what these sections are at this point. Consider removing this information or making it clearer to the reader. E.g., 'specific sections located near to the town of…'.

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

Under the 20-year rainfall condition, the percentage of units with high risk and extremely high risk is 7.11%. The prediction results can help adjust the design of water and soil conservation measures for these units.

Comment 6: Paragraph starting line 43 has no references and should be supported by citation to the literature.

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

China has gradually accelerated the construction of highways in recent years and subsequently improved transportation networks and driven rapid economic development (Jia et al., 2005)

Reference:

Jia, Y. H., Dai, D. C., Liu, Y.: Performance Analyse and Evaluation of Freeway in China. JOURNAL OF BEIJING JIAOTONG UNIVERSITY, 29(6):1-5, 2005 (in Chinese)

Comment 7: Line 55 sentence starting 'According to statistics, with the development of highway..' is somewhat unclear and needs rephrasing. Do you mean something like 'on an annual basis, highways are constructed through 200-300 km2 per year'. Square kilometres rather than square meters also seem more appropriate for numbers here.

Response 7: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

Statistics further indicate that in the next 20–30 years, the expressways in China will measure more than 40,000 km. For every kilometre of highway, the corresponding bare slope area is expected to measure 50,000–70,000 m^2 (Wang, 2006).

Reference:

Wang, C. J.: Regional Impaction and Evolution of Express Way Networks in China. PROGRESS IN GEOGRAPHY, 25(6):126-137, 2006 (in Chinese)

Comment 8: Line 82 influence should be influences or influenced-depending on whether you are using past tense for 'believed'.

Response 8: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

Tresch et al. (1995), in a study of Switzerland, argued that the slope length (L) or slope steepness factor (S) is one of the main factors of soil erosion prediction, and these parameters significantly influenced the erosion values calculated by RUSLE.

Comment 9: Line 84, why do you say 'particularly in Switzerland'? This seems a little strange as up to now the work has focussed on China. If Tresch focuses on Switzerland then mention this earlier on, e.g. 'Tresch et al. (1995) in a study of Swiss..'

Response 9: We greatly appreciate your valuable suggestion concerning improvement to this

paper. We have followed your advice to revised it. Details are in following paragraph and manuscript.

Tresch et al. (1995), in a study of Switzerland, argued that the slope length (*L*) or slope steepness factor (*S*) is one of the main factors of soil erosion prediction, and these parameters significantly influenced the erosion values calculated by RUSLE. All existing S factors can be derived only from gentle slope inclinations of up to 32%; however, many cultivated areas are steeper than this critical value.

Comment 10: Line 88 citation should not have initials. This seems to be a problem throughout.

Response 10: Thank you for your patience and careful work! We have revised this sentence again, details are in following paragraph and manuscript.

Rick (2001) found that using universal soil loss equation (USLE) and RUSLE soil erosion models at regional landscape scales was limited by the difficulty of obtaining an *LS* factor grid suitable for geographic information system (GIS) applications.

Comment 11: Line 97 Define the parameter K

Response 11: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

Silburn (2011) showed that estimating soil erodibility factor (*K*) from soil properties (derived from cultivated soils) provided a reasonable estimate of *K* for the main duplex soils at the study site as long as the correction for the undisturbed soil was used to derive K from the measured data prior application to the USLE model (Silburn, 2011).

Comment 12: Sentence starting at the end of line 103 goes over five lines and is quite difficult to read. Please split into smaller sentences.

Response 12: Thank you for your comments! We have followed your advice to revise it, we hope to meet your requirement. Details are in following paragraph and manuscript.

Chen (2010), who initially considered the terrain characteristics of roadbed side slopes and conducted concrete analysis of the terrain factor calculation method in RUSLE, appraised the

compatible terrain factor computational method of roadbed side slope and proposed a revised method based on the measured data of soil erosion in the subgrade side slope of Hurongxi Expressway (from Enshi to Lichuan) in Hubei Province.

Comment 13: Line 131 Define what the C factor is.

Response 13: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

The method was better than the commonly used techniques based on green vegetation (e.g. normalised difference vegetation index (NDVI)) only, and it was appropriate for estimating the vegetation cover management factor (*C*) in the model led hillslope erosion in New South Wales, Australia by using emerging fractional vegetation cover products.

Comment 14: Line 181 mention the method of rainfall interpolation and add references here. I suggest commenting on some of the uncertainties of interpolation in regions with steep topography as at present this is presented as somewhat of a perfect solution.

Response 14: We greatly appreciate your valuable suggestion concerning improvement to this paper. We have followed your advice to revised it. Details are in following paragraph and manuscript.

In this study, we analyse the following characteristics of soil erosion to improve certain aspects expressway construction based on previous research: (1) We divide the highway slope into natural and artificial units and calculate the amount of soil loss from the slope surface to the pavement based on the slope surface catchment unit. Considering that this approach is in line with the actual situation, the findings can thus can be popularised. (2) Previous studies have shown that the spatial interpolation method of precipitation has been stagnant in the study of the spatial and temporal distribution of precipitation in mountain areas (Liu and Zhang, 2006). At the same time, the problem involves two aspects. From the timescale perspective, the characteristics of rainfall distribution and the influencing factors are not fully considered. From the spatial scale perspective, the spatial heterogeneity of the region is ignored. Many studies have limited the factors affecting precipitation to altitude factors, thereby leading to low interpolation accuracy (Zhao et al., 2011;

Liu et al., 2010). Thus, we consider the spatial heterogeneity of linear engineering of the expressway. Then, the rainfall factor is spatially interpolated to compensate the following limitations: shortage of rainfall data of mountain areas; difficulty of representing the rainfall data of an entire expressway by using those data from a single meteorological station; and uneven spatial distribution and strong heterogeneity of rainfall in mountain areas (Li et al., 2017). (3) We modify the parameters of the artificial slope by actual survey, runoff plot observation and other methods, and the parameters of the artificial slope are corrected by referring to the form of the project and the utilised materials. In this study, we not only scientifically predict the amount of soil erosion caused by highway construction in mountain areas but also provide a scientific basis for the prevention and control of soil erosion and the rational allocation of prevention and control measures. Moreover, the safe operation of highways and the virtuous cycle of the ecological environment should be ensured to promote the sustainable development of the local economy.

Reference:

Li, Y., Qi S., Cheng, B. H., Ma, J. M., Ma, C., Qiu, Y. D., Chen, Q. Y.: A Study on Factors of Space-time Distributions of Precipitation in Ailao Mountain Area and Comparison of Interpolation Methods. EARTH AND ENVIRONMENT, 45(6): 600-610 (in Chinese)

Liu, J. T., Zhang, J. B.: Interpolation analysis of the spatial distribution of precipitation in mountain area. Journal of Irrigation & Drainage, 25:34-38, 2006 (in Chinese)

Zhao, C. C., Ding, Y. J., Ye, B. S., Zhao, Q. D.: Spatial distribution of precipitation in Tianshan Mountains and its estimation. Advance in water science, 22:315-322, 2011 (in Chinese)

Liu, Z. Y., Zhang, X., Fang, R. H. Analysis of spatial interpolation methods to precipitation in Yulin based on DEM. Journal of Northwest A&F University (Nat. Sci. Ed.), 38:227-234, 2010 (in Chinese)

Comment 15: Sentence on line 203 English language needs some work.

Response 15: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

Between May and the middle of October, the area experiences wet season characterised by

abundant rainfall, concentrated precipitation and increased rain at night time; the variation of precipitation is 400–2000 mm, whilst most regions have 800–1800 mm (Fei et al., 2017; Zhang et al., 2017).

Comment 16: Equation 4. There is some variability in the number of decimal places used for different variables. These should be consistent and reflect the precision of the original data. Does e represent Euler's number here, or is it a parameter? Please state.

Response 16: Thank you for your comments! We have followed your advice to explain it. Details are in the following paragraph.

In equation 4, the decimal is an empirical parameter whose value is fixed, and it has no variability. 'e' is the base number of natural logarithm and an infinite non recurring decimal.

Comment 17: Figure 6. As with figure 5, it is very difficult to distinguish the slope units with the colour scheme you have chosen, and this will not work in greyscale.

Response 17: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

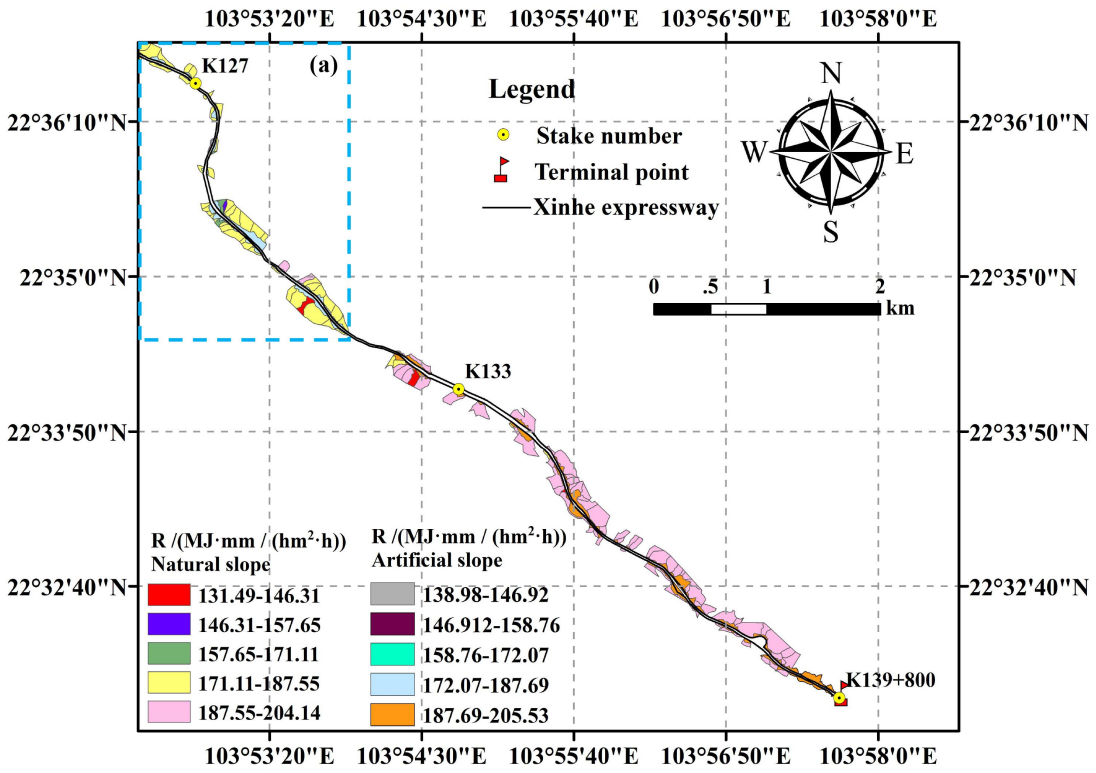

Figure 5. Spatial distribution map of rainfall erosivity factors (K127–K139+800)

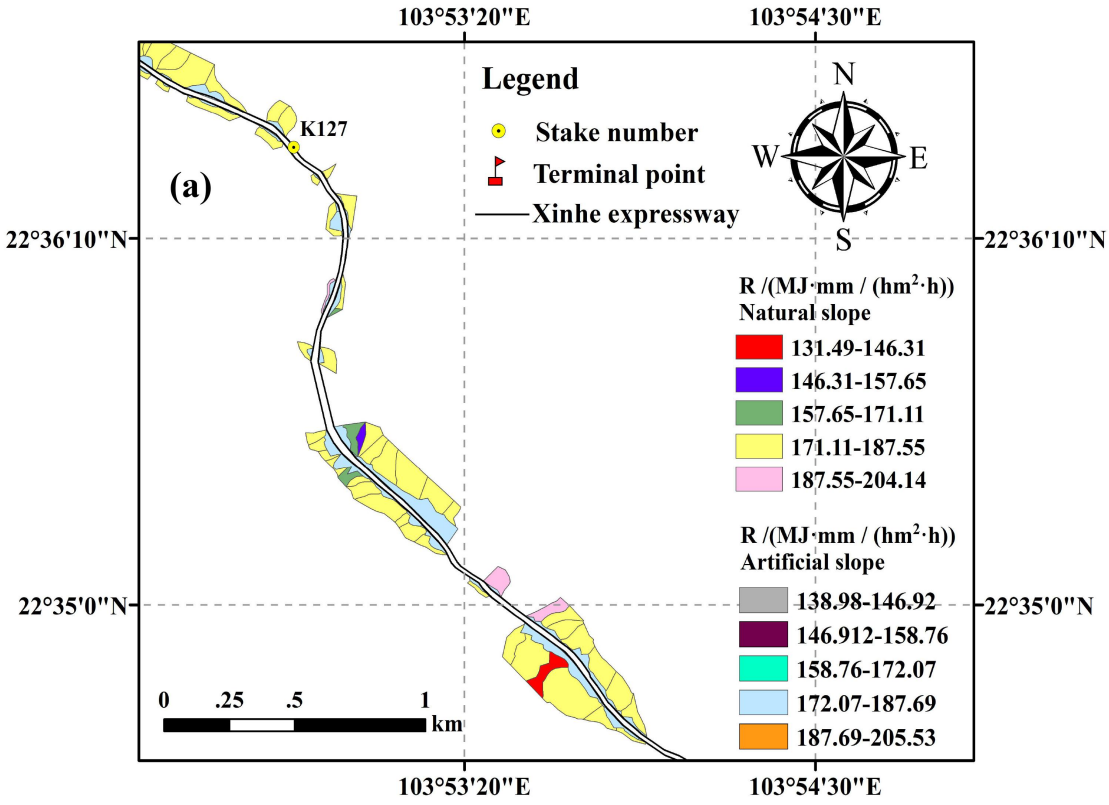

Figure 5(a). The subgraph of Figure 5 with zoomed sections

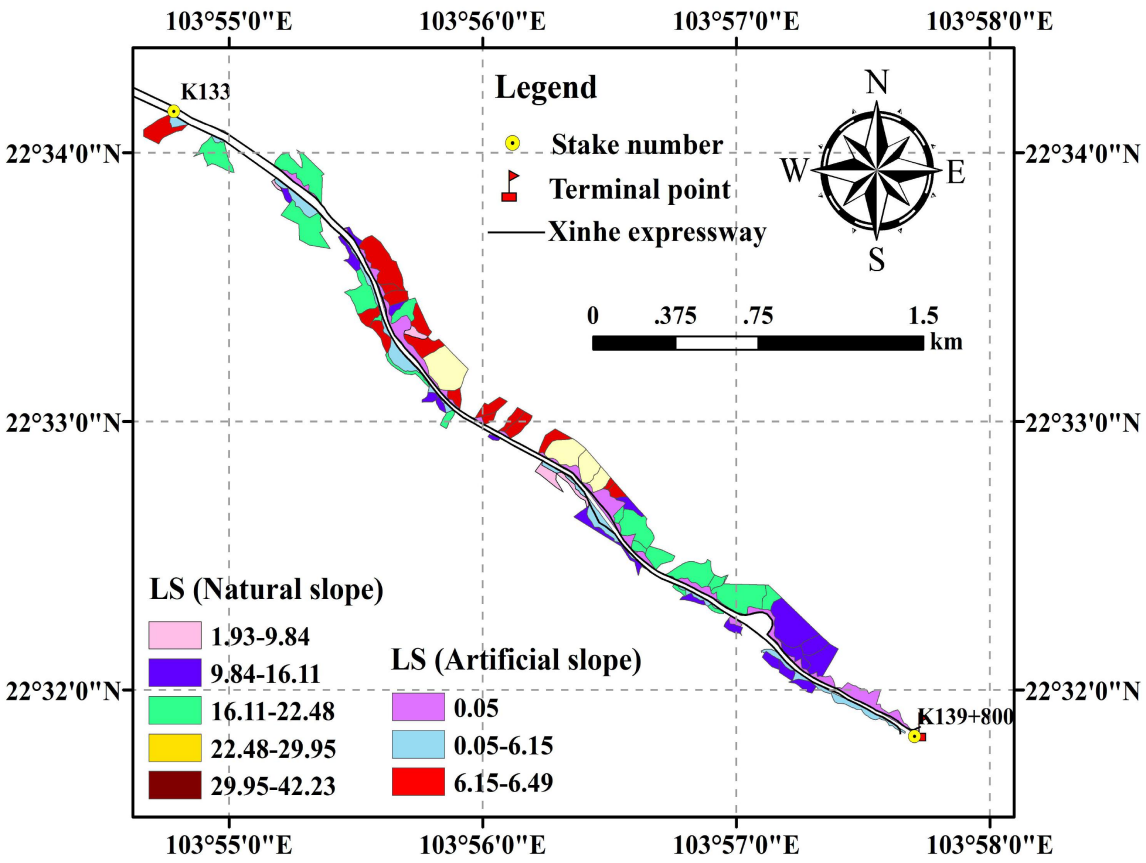

Figure 6. Spatial distribution map of topographic factors (K134–K139)

Comment 18: Table 5 and 6 would be better presented as figures (e.g., bar or line charts) as it is very hard to visually discern any trends or differences in the raw numbers. If needed, you could put the corresponding table into an appendix.

Response 18: We are in complete agreement with your comment. The author did not analyze and compare the data in Table 5 and table 6, the two tables are mainly a demonstration of the result of calculation. Therefore, we decided to take the two tables as appendices. Details are in the manuscript.

Comment 19: Line 411. 'The research method of Chen Zongwei' is this a reference? Please put in an appropriate format.

Response 19: Thank you for your patience and careful work! We have followed your advice to revise it. Details are in the following paragraph and manuscript.

The method of Chen Zongwei (2010) was adopted for the calculation of the *LS* factor of the artificial slopes

Reference:

Chen, Z. W., He, F., and Wang, J. J.: Revises of Terrain Factors of Roadbed Side Slope in Universal Soil Loss Equation. HIGHWAY, 12:180-185, 2010 (in Chinese).

Comment 20: Line 435 double bracket should be removed.

Response 20: Thank you for your patience and careful work! We have followed your advice to revise it. Details are in the following paragraph and manuscript.

The *C*-factor after topographic analysis is considered an important factor soil loss risk control. In the RUSLE model, the C-factor is used to depict the effects of vegetation cover and management practices on soil erosion rate (Vander-Knijff et al., 2000; Prasannakumar et al., 2011; Alkharabsheh et al., 2013).

Comment 21: Figure 14 is good (where you show several segments of road in 'strips') and I suggest using a similar format for figures 5 and 6. Figure 14 and 15 please put a description of the variables in the legend caption. I.e., this is Risk within a natural slope, not just 'natural slope'.

Response 21: Thank you for your comments! We have followed your advice to revise it. Details are in following paragraph and manuscript.

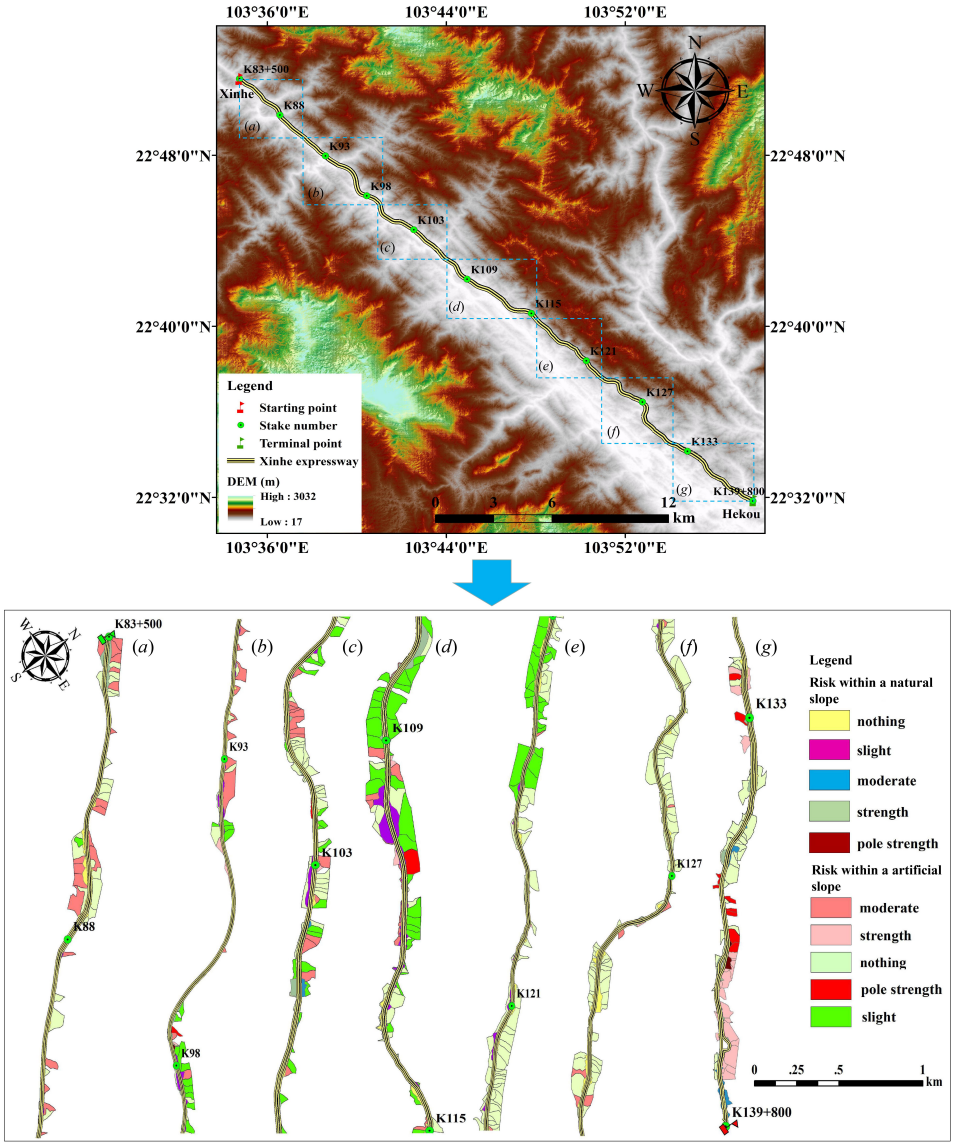

Figure 14. Risk analysis of soil and water loss under 20-year rainfall conditions

Figure 15. Risk analysis of soil and water loss for the 1-year rainfall amount

Comment 22: Figure 13 please put a description of the variable I within the legend caption.

Response 21: Thank you for your comments! We have followed your advice to revise it. So that you can interpret the meaning of this Figure more clearly. Details are in following paragraph and manuscript.

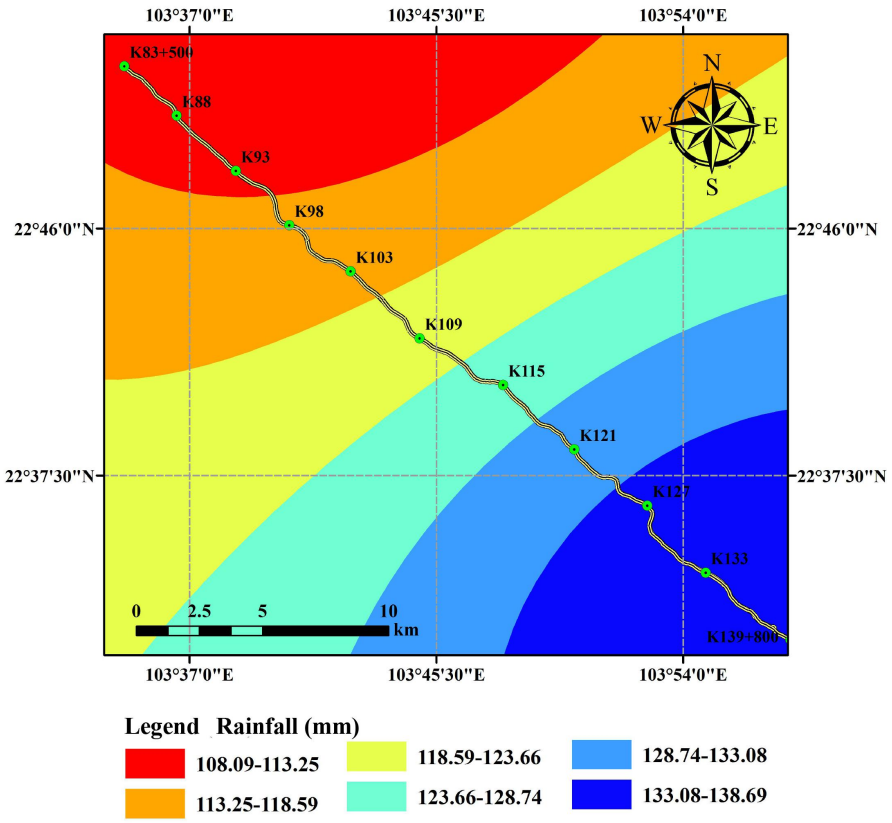

Figure 12. Rainfall interpolation results under 20-year return

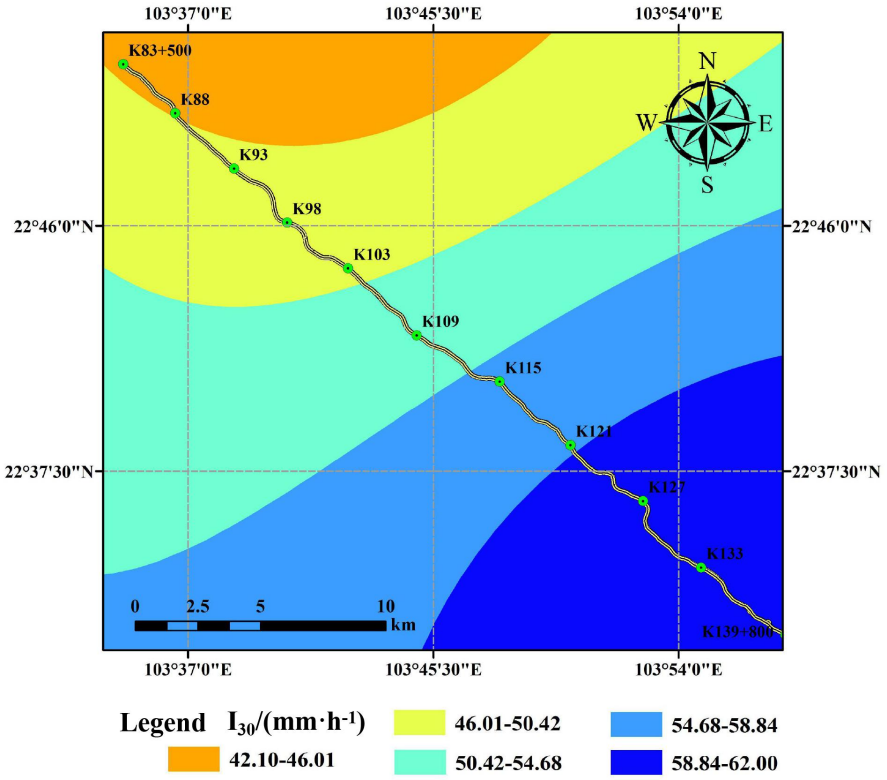

Figure 13. Rainfall intensity interpolation results under 20-year return

Comment 23: Sentence starting on line 550 is 8 lines long and hard to read. Please split into shorter sentences.

Response 23: Thank you for your patience and careful work! We have followed your advice to revise it. Details are in the following paragraph and manuscript.

The RUSLE model can also be used to predict soil erosion of natural slopes. On the premise that rainfall erosivity variations have not been considered, we find that the methods of model parameter acquisition are consistent in the literature analysis and comparison for areas of the same type (Yang 1999; Yang 2002; Peng et al., 2007; Zhao et al., 2007; Chen et al., 2014; Zhu et al., 2016). Moreover, after comparing the monitoring data with runoff plots, we find that the error between the predicted value and the monitoring value calculated by the RUSLE model is negligible (Yang 1999; Yang 2002; Li et al., 2004). These findings indicate that the prediction results of the model are reliable.

Comment 24: The discussion section is good in that it brings the findings back into the literature. However, the English needs some work here.

Response 24: Thank you for your comment! We have followed your advice to revise it. We hope to meet your requirement. Details are in the following paragraph and manuscript.

4 Discussion

Slope is the main factor of soil and water loss caused by highways. Thus, slope is very important for prediction and early warning systems. A highway slope can be divided into natural and engineering (artificial) slopes. The RUSLE model can also be used to predict soil erosion of natural slopes. On the premise that rainfall erosivity variations have not been considered, we find that the methods of model parameter acquisition are consistent in the literature analysis and comparison for areas of the same type (Yang 1999; Yang 2002; Peng et al., 2007; Zhao et al., 2007; Chen et al., 2014; Zhu et al., 2016). Moreover, after comparing the monitoring data with runoff plots, we find that the error between the predicted value and the monitoring value calculated by the RUSLE model is negligible (Yang 1999; Yang 2002; Li et al., 2004). These findings indicate that the prediction results of the model are reliable. In the prediction of slope erosion of engineering (artificial) slopes, previous studies have emphasised surface disturbance during construction (He, 2004; Liu et al., 2011; He, 2008; Hu, 2016; Zhang et al., 2016; Song et al., 2007) but did not consider soil erosion as a result of the construction. In the process of predicting soil and water loss in engineering slopes by using the RUSLE model, the correction of the

conservation support practice factor (i.e. cement block and hexagonal brick) is often ignored (Zhang, 2011; Morschel et al., 2004; Correa and Cruz, 2010). In addition, most cases use RUSLE modelling to predict the soil erosion of highway slopes. Remote sensing is usually based on grid data but does not consider catchment units (IsIam et al., 2018; Villarreal et al., 2016; Wu and Yan 2014; Chen et al., 2010).