Dear Editors and Reviewer:

Thank you for your letter and for the reviewers' comments concerning our manuscript entitled "Characteristics and RISM of sliding flow landslides triggered by prolonged heavy rainfall in the loess area of Tianshui, China" (ID: nhess-2022-135). Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. We have studied comments carefully and have made correction which we hope meet with approval. The authors upload the both file (one is revised with tracking word and the other is revised without tracking word). The main corrections in the paper and the responds to the reviewer's comments are as flowing:

Responds to the reviewer's comments:

## Reviewer: 1

The present study aims to improve prediction model for the shallow loess landslides induced by prolonged heavy rainfall.

The outstanding work is the improvement of the Taylor slope infinite model, based on equal differential unit method, permitting to correct the error when the safety factor increases with the increased slope when the slope is larger than 50°. Moreover, the intensity duration (I-D) prediction curve is proposed for the shallow loess landslides, considering the characteristics of rainfall infiltration, and different slopes.

Responded: Thank you very much for your comment. Just like the reviewer suggestion, the main purpose of this manuscript is to improve the deficiency that the safety factor invariable or increases with the slope increasing when the slope is larger than 40° calculated using the Taylor slope infinite model using equal differential unit method, and try to build a forecast model for rainfall-induced shallow landslides based on physical processes. The authors just improve the Taylor slope infinite model using equal differential unit method, and based on rainfall infiltration, a physical prediction model of rainfall-induced shallow landslides is proposed. The process proposed of prediction model of rainfall-induced shallow landslides in this study can provide an idea for subsequent software development and improved, and may be applied to many software, such as the SINMAP, SHALAD etc. Although there are some shortcomings, the author believes that the method proposed in this manuscript has a good reference for future shallow landslide prediction and promote the integration of statistical and physical models.

But several misunderstanding are encountered in this paper:

- the study is focused on the development of RISM model, for a better estimation of safety factor for slope higher than 50°. However, as seen from field data (in figure 7), all landslides are triggered in slopes lower than 35°. In that way, we do not really understand why the development of this model can help in quantifying the stability of slope in this context.

Responded: Thank you very much. This is a particularly good suggestion. It is difficult to reach the landslide location when the slope greater than 35° and conduct field measurements during the field investigations. So, the 89 landslides measured in the field investigation were within the range of 35°. However, it can be seen from the figure 1 that the "7.25" Tianshui sliding-flow landslides is mainly distribution between 20-50°, and more than 50% of the sliding-flow landslides are located in slope with greater than 35° according to all the "7.25" Tianshui sliding-flow landslides data. the main purpose of this manuscript is to improve the deficiency that the safety factor invariable or increases with the slope increasing when the slope is larger than 40° calculated using the Taylor slope infinite model using equal differential unit method, and try to build a forecast model for rainfall-induced shallow landslides based on physical processes. The I-D prediction model based on physical process proposed in this manuscript has a clear physical process considered different slope characteristics can give the higher prediction accuracy.

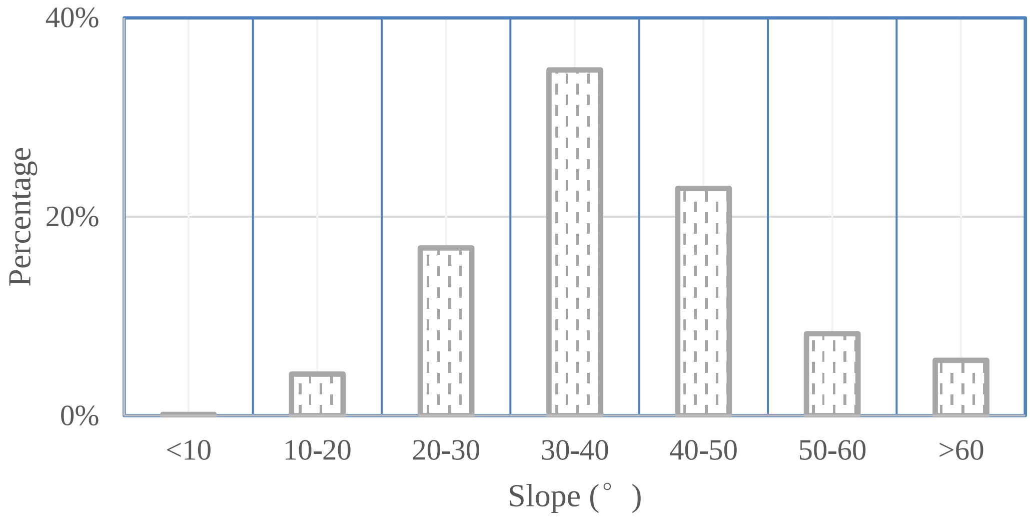


Fig. 1 The distribution of the "7.25" Tianshui sliding-flow landslides vs slope

- Moreover, the validation of the approach (notably the I-D curve for different slopes) is not realised, as the I-D curves for different slopes are not tested in real case for all landslides.

Responded: Just like the reviewer comment, the authors did not calculate the I-D curve for all slopes. The "7.25" Tianshui sliding-flow landslides is mainly distribution between 20-50°, and more than 50% of the sliding-flow landslides are located in slope with greater than 30-45° according to all the "7.25" Tianshui sliding-flow landslides data. So, I-D curves for different slopes in the manuscript are not tested suing the range of 30-45 degrees (Figure 14). Calculating all the slope I-D curves has little effect on the regional shallow landslide prediction. It should calculate the I-D curve according to the dominant slope or the dominant slope of shallow landslides for regional shallow landslide prediction. And, the I-D curve of a single slope can be built according to the slope gradient and physical parameters for the prediction of a single slope.

- Several key information and references are missing, such as: the methodology for obtaining the landslide's map; the justification about how the 89 studied landslides are representative of the 45 000 landslides; the initial I-D curve that has been used in this study.

Responded: Thank you very much. The authors have added the information about the map for obtaining the landslide's map in section 3.1. Now, many high-resolution satellite data are free, such as GE and other data. The author uses the google earthed data source, which provides historical images, which can be used for sliding-flow landslide interpreted. Remote sensing images (~2 m resolution from Google earth images) from October 2012 (before the sliding-flow landslide event) and December 2013 (after the sliding-flow landslide event), before and after the sliding-flow landslides were used for sliding-flow landslide interpreted in this manuscript. For the question of how 89 landslides represent 45,000 landslides, it is impossible to obtain the sliding surface depths of 45,000 landslides, because measuring the sliding surface depths requires manual measurement in the field investigation. The authors mainly want to give the information that the relationship between the sliding surface depth and slope, area of the landslides using the 89 landslides. Therefore, the relationship between the sliding surface depth and the slope, area of the 89 landslides in this manuscript is to explain the close relationship between the sliding surface depth and the slope. It provides data support for constructing I-D curves under different slopes.

Based on these main elements, I suggest to reject the manuscript.
You can also find below some additional comments:
Line 89 "7.25" loess sliding-flow landslide events in Tianshui Gansu province : please define the meaning of "7.25", otherwise you have to add the reference to this.
Responds: It is very good suggestion, thanks very much. Considering the Reviewer's suggestion, the authors have changed the landslide event to 2013 Tianshui sliding-flow landslide event and added information about the meaning of 2013 Tianshui sliding-flow landslide event according to the landslide occurred date in the section 1. (???).

Figure 1 is not a geomorphological nor geological map; please put elements concerning these 2 features ; moreover, earthquake location is not usefull to this paper, as the study works on landslides induced by heavy precipitations, and not by earthquake.
Responded: Thank you for the reviewer's suggestion. Considering the Reviewer's suggestion, the authors have redrawn the Figure 1 and added the topographic, land use and loess thickness that have the most direct impact on shallow landslides occurrence in the Figure 1.

I suggest to dedicate paragraph 2 to geological, geomorphological, and climate characteristics ; as the threshold of these landslides is heavy precipitation, I recommend to detail the climate description in a sub-paragraph 2.2 (subparagraph 2.1 could be geological and geomorphological characteristics) ; finally I suggest to move 2.2 to paragraph 3, as it concerns landslides features.
Responded: Thank you for the reviewer's suggestion. Considering the Reviewer's suggestion, the authors have revised section 2 in detail. In section 2.1, the authors focused on describing the geographic, geomorphological, and climate characteristics of the region; in section 2.2, the authors introduced the climate of the region, especially the information on extreme rainfall events in recent decades. And, transfer the landslide information to section 3.

I think it is necessary to detail input data and the processes to obtain landslides maps, with some zoom on figure 2.
Responded: Thank you very much. Considering the Reviewer's suggestion, the authors have added the information about the map for obtaining the landslide's map in section 3.1. Now, many high-resolution satellite data are free, such as GE and other data. The author uses the google earthed data source, which provides historical images, which can be used for sliding-flow landslide interpreted. Remote sensing images (~2 m resolution from Google earth images) from October 2012 (before the sliding-flow landslide event) and December 2013 (after the sliding-flow landslide event), before and after the sliding-flow landslides were used for sliding-flow landslide interpreted in this manuscript. By comparing the remote sensing images before and after the event, the shallow landslide induced by the 2013 Tianshui sliding-flow landslide event can be clearly distinguished, as shown in the flowing figure.


Figure 2 Remote sensing images before and after the event. (a: before the sliding-flow landslide event, b: after the sliding-flow landslide event)

table 2 : the term “area” is not appropriate ; you can use “surface area”

Responded: Thank you very much. Considering the Reviewer’s suggestion, the authors have used “surface area” replace the term “area” in the table 2.

Line181 : you have to indicate and discuss whether these 89 landslides are statistically representative of the 47 005 landslides ; you also have to precise the characteristics of the landslide you consider for obtaining the depth of the landslide.

Responded: Thank you very much. For the question of how 89 landslides represent 45,000 landslides, it is impossible to obtain the sliding surface depths of 45,000 landslides, because measuring the sliding surface depths requires manual measurement in the field investigation. The authors mainly want to give the information that the relationship between the sliding surface depth and slope, area of the landslides using the 89 landslides. Therefore, the relationship between the sliding surface depth and the slope, area of the 89 landslides in this manuscript is to explain the close relationship between the sliding surface depth and the slope. It provides data support for constructing I-D curves under different slopes.

The authors very agree with the comment that precise the characteristics of the landslide you consider for obtaining the depth of the landslide. It is difficult to reach the landslide location when the slope greater than 35° and conduct field measurements during the field investigations. So, the 89 landslides measured in the field investigation were within the range of 35°. However, the “7.25” Tianshui sliding-flow landslides is mainly distribution between 20-50°, and more than 50% of the sliding-flow landslides are located at slope with greater than 35° according to all the “7.25” Tianshui sliding-flow landslides data. The authors mainly want to give the information that the relationship between the sliding surface depth and slope, area of the landslides using the 89 landslides. Therefore, the relationship between the sliding surface depth and the slope, area of the 89 landslides in this manuscript is to explain the close relationship between the sliding surface depth and the slope. It provides data support for constructing I-D curves under different slopes.

figure 7 is confusing, as slope and surface areas are in the same graph. 2 separate graphs might be better

Responded: Thank you very much. Considering the Reviewer’s suggestion, the authors have separated the graphs in the figure 7 and made it clearer.

line 200 : it is necessary to provide details and possible explanation about “a certain depth of loess becoming close to liquid limit water content” : which depth? Depending on what?

Responded: Thank you for the suggestion. In the section, the authors described the mode and process of sliding-flow landslide induced by prolonged heavy rainfall. According to a large number of field monitoring and previous research results, this specific depth is generally considered to be a depth of 1-2m, the author adds references in the sentence.

line 209 : please provide references concerning the depth of shallow landslides in loess.
Responded: Thank you for the suggestion, the authors have added references in the sentence.

P12 line 214 : it is mentioned that "loess landslide transformation to mudflows occur most often on slopes of 25 – 45°" ; why is it different from the results shown on figure 7? Please explain.
Responded: Thank you very much. It is difficult to reach the landslide location when the slope greater than 35° and conduct field measurements during the field investigations. So, the 89 landslides measured in the field investigation were within the range of 35°. However, it can be seen from the figure 1 that the "7.25" Tianshui sliding-flow landslides is mainly distribution between 20-50°, and more than 50% of the sliding-flow landslides are located in slope with greater than 35° according to all the "7.25" Tianshui sliding-flow landslides data.

line 220 ; provide reference of Taylor;
Responded: Thank you for the suggestion, the authors have added references in the sentence.

line 222 ; the length of the body is b, not l
Responded: Thank you for the suggestion, the authors have revised the sentence and changed the *l* to *b*.

figure 9 ; I don't understand the different directions of arrows designing the flow lines ?
Responded: Thank you for the suggestion, the figure 9 is drawn with reference to Tylor's infinite slope model, the authors have added references.

Fig 10 : how do you chose the value c' phi', gsat ? for high slopes, I am not sure that such value can be found in the field
Responded: Thank you very much. The Figure 10 is to illustrate the phenomenon that the safety factor invariable or increases with the slope increasing when the slope is larger than 40° calculated using the Taylor slope infinite model using equal differential unit method. So the value of the c' phi', gsat is used the mean strength of saturated loess in the loess area which obtained based on loess at 25% water content (saturation 84%). The figure just shows that Taylor slope infinite model cannot be used to calculate the safety factor of shallow landslides when the slope is higher than 4°. The authors have added the information in the text.

p15, line 292 : please provide some details or references on loess test results ; the figure 13 doesn't provide these elements
Responded: Thank you for the suggestion, the authors have added the test method and the value of the c,and phi' used in the Figure 13 has provide in the text. The value of the c,and phi' used in the Figure 13 is based on the mean strength of saturated loess in the study area.

line 298 : it is necessary to plot this law on figure 13
Responded: Thank you for the suggestion, the authors have added the law on figure 13.

figure 14 : we don't know what is Yan'an "7.13" group shallow landslide . Which are the values of the characteristics used here (C, phi, rainfall events, slopes ….)? more generally, how are constructed these curves ? is it still the parameters c, phi, … from figure 10 that are considered?

Responded: It is very good suggestion, thanks very much. The value of the c,and phi' used in the Figure 14 iare same as the Figure 13 which has provide in the text. The value of the c,and phi' used in the Figure 13 is based on the mean strength of saturated loess in the study area. Considering the Reviewer's suggestion, the author have added the information in the Figure 13 and Figure 14. The Yan'an "7.13" group shallow landslide was also a group-occurring shallow sliding-flow landslide event induced by prolonged heavy rainfall in 2013. The loess in the Yan'an and Tianshui have similar properties and both belong to the Loess Plateau. Therefore, the authors used the both mass shallow sliding-flow landslide events in 2013 to verify the feasibility of the I-D curve built in the manuscript. The I-D curve of Figure 14 is based on Equations 8 and 9, where hw is from Figure 13. According to different slopes, referring to the parameters in Figure 10, the Figure 14 can be obtained. The authors have added information in the text.

I don't see here really validation of the model or approach ; you could apply this I-D curve on the all area of study, with considering for each local area or pixel I-D curve, considering local parameters. I don't understand how you can consider the "7.25 loess sliding-flow events" as a unique point on your analysis.

Responded: Thank you for the suggestion. The I-d curve is the most common and widely used method for predicting regional shallow landslides currently. The authors give the I-D curves under different slopes in Figure 14 and uses 7.25 Tianshui sliding-flow landslide event for verification. For the question of why a regional landslide event has only one point, because rainfall events are regional, a rainfall event has only one rainfall duration and intensity, and the induced slopes may be located on different slopes. Calculating all the slope I-D curves has little effect on the regional shallow landslide prediction. It should calculate the I-D curve according to the dominant slope or the dominant slope of shallow landslides for regional shallow landslide prediction. And, the I-D curve of a single slope can be built according to the slope gradient and physical parameters for the prediction of a single slope. At present, there are only a few mass sliding-flow landslide events in loess area, and there are only these two events with detailed i-d records, so the author uses these two events for verification.

figure 15 : legends of the curves are missing, we have no information on them

Responded: Thank you for the suggestion, the authors have added the legend in the Figure 15.

paragraph 5.2 : why this part is within the discussion paragraph ?

Responded: Considering the Reviewer's suggestion, the authors have deleted the section of sensitivity analysis and added a section to discuss the limitations of the model and discuss the impact of vegetation on sliding-flow landslides due to many sliding-flow landslides occur in areas with better vegetation coverage.

As a general comment, the discussion is not really realised.

Responded: Considering the Reviewer's suggestion, the author has added a section to discuss the limitations of the model and discuss the impact of vegetation on sliding-flow landslide, because many sliding-flow landslides occur in areas with better vegetation coverage.

Figure 16 : as figure 7, the figure is confusing ; it is better to provide One graph for each parameter;

Responded: Thank you for the suggestion, the authors have deleted the Figure 16.

line 349 : there are errors in internal friction angle, expressed in kPa!
Responded: Thank you for the suggestion, the authors have revied in the text.

The paper requires proofread by English native speakers, as it encounters several English mistakes or inadequate words, as well as sentences wrong formulation. Indeed, several sentences are not clear; for instance:

1, line 13
1, lines 16 to 18 : sentence too long
3, line 95 : you mean "the elevation of the study area" ? please check
17, line 331 : non comprehensive sentence
17, line 333, 334 : I don't understand

Responded: Thank you for the suggestion, the authors have polished the manuscript by native English speaker.

Yours sincerely,

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