Reviewer 1:

Although I agree with the responses regarding to my previous comments, there are still some problems as I annotate in the attached PDF. Please take care of them.

For example:

Figure 6: 'acceleration'? The unit of vertical axis is (mu m/s), and it is a velocity unit! Please make sure of it! Also, most broadband devices measure velocity.

Many lengthy sentences shall be improved. I also suggested the whole text has to be prove read thoroughly by native English speakers for correct and accurate descriptions before its publication.

We are thankful to our reviewer's comments of the present study. Figure 6 is the time-domain velocity curve, and we have now modified the relevant descriptions. And we have modified the long sentences and have examined English carefully.

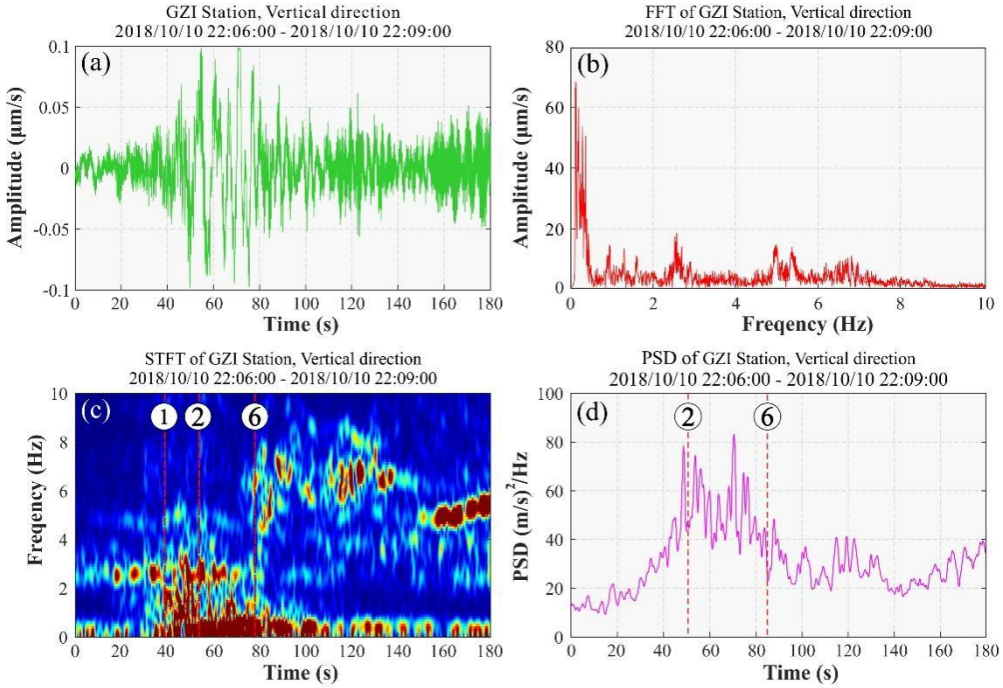
We have made all the modifications to the above problems, as follows:

1. l75: We have modified "no-seismic" to "non-coseismic".
2. l135-l138: In this study, we use long period seismic signal to obtain the dynamic characteristics of Baige landslide, China, which occurred on October 10, 2018 (termed as the "10.10" event). Combined with the inversion results, the landslide process was reconstructed by numerical simulation. Through seismic signal analysis, landslide dynamic inversion and numerical simulation, combined with the post-event field investigation, we try to provide an improved characterization of the landslide movement process.
3. l161: We have added the explain of "DOM" as "Digital Orthophoto Map (DOM)".
4. l163-l166: We have revised this sentence to "SA1 and SA2 is two main accumulation zone, the debris of SA1 is main from shear area, while SA2 main from main slip area and blocking area; SA3 is the left bank of the river, scoured by landslide debris; SA4 is a small area of the right bank scoured by landslide debris; SA5 is the downstream left bank, which is affected by the landslide body mix with the sandblasting water".
5. l200: We have modified the legend as "Red line in the PSD image is NHNM and green line is NLNM".
6. l300: We have deleted the extra quotes.
7. l311: We have modified "adjusted" to "adjust and".
8. l404: We have modified "acceleration" to "velocity".
9. l408: We have modified "channel" to "path".

10. l418: We have modified the caption as: “Fig. 6. Time-domain velocity signal (E \N\V direction) of the seismic generated...”.

11. l432、l434: We have modified “acceleration” to “velocity”.

12. l468: As instructed, we have revised Fig. 7(b).



13. l484: We have revised this sentence to “... and the morphology in the time-frequency domain and time domain presents single-peak or double-peak characteristic; while the frequency of flood or high-density flow seismic signals is usually high (5~50 Hz), and its morphology in the time-frequency domain and time domain is mostly flat”.

14. l618: It means that they have similar lower cut off frequencies. We have modified this sentence to “Since the frequency bands that we used in the two inversions have similar lower cut off frequencies”.

15. l751-l752: We did not express it accurately enough, and we have now revised “concentrating” to “constraining”.

16. l760: We have modified “accretion” to “depositional”.

17. l762: We have modified “mega-landslides” to “depositional morphology”.

18. l784: We have modified “friction weaking” to “friction coefficient decreases as the landslide progresses”.

Reviewer 2:

In comparison to the first version of the manuscript, this new version has been greatly improved. The contributions, the aim, and the methodology is now clearer. The authors chose not to move some methodological parts from the Results section to the Methodology section. I understand their point of view that it helps clarifying some explanation. Yet, I still think it would be better to separate the Methodology from the Results to clarify the whole process, from seismic analysis to simulation calibration, including the intermediate steps of trajectory reconstruction, mass estimation and acceleration/deceleration phases identification. However, this is not a reason not to accept this manuscript, and I recommend its publication.

I still have some comments though, and in my opinion, some minor modifications are still needed before publication. They are detailed in the attached file. In any case, I commend the authors for this very nice work.

We would like to thank the reviewer for his helpful comments regarding our manuscript. In response, we have further revised the manuscript. Below, we provide details regarding our revisions.

Main comments

C1: l.117-133: I would present the three methods in this order: 3D continuum, 2D continuum (i.e. thin-layer models), discrete models. Because in the paragraph starting at l. 134, you talk about MatDem that is a discrete model. It would thus be a more logical transition.

R1: Thank you for your constructive comments. As instructed, we have now modified the order, as follows:

"The continuous medium approach, including smoothed particle hydrodynamics (SPH) (Pastor et al., 2014), material point method (MPM) (Soga et al., 2016), finite element method (FEM) (Muceku et al., 2016), finite volume method (FVM) (Pitman et al., 2003), and finite difference method (FDM) (Shen et al., 2020), is not very effective in describing particle separation and internal fracture of rockslides. The thin-layer models are based on the thin-layer approximation and depth-averaging of the Navier–Stokes equations without viscosity, but a main issue is low computational accuracy (Moretti et al., 2012, 2015; Yamada et al., 2016, 2018). The discrete element approach utilizes software such as particle flow code (PFC) (Lo et al., 2011; Zhang et al., 2020a) and DEM solutions (EDEM) (Wang et al., 2020c), but a major issue is low computational efficiency".

C2: l.146 – 158: It is still not clear, at this point in the manuscript, if simulations have already been performed in previous studies for the Baige landslide (see my previous

comment C8). I think the studies are cited in the manuscript, certainly in the introduction, but the reader does not know if the simulations were performed on the Baige landslides, or on other landslides. Thus, I would be more specific (in the introduction or in the "Study area" paragraph), saying XX did that, YY dit that, etc. Then, in the discussion, these previous studies can be compared to the present one, which the authors do well.

R2: Thank you for your advice, we rewrote "Study area" paragraph as follows:

"A massive landslide occurred at Baige, on the eastern Qinghai-Tibetan Plateau, China, on October 10, 2018 (termed as the "10.10" event) (Fig. 1). The landslide caused the blockage of the main stream of Jinsha River and formed a barrier lake. On October 12, the water of the barrier lake began to discharge naturally until all the discharge was completed on October 13. On November 3, 2018, the rock and soil mass at the trailing edge of the slide source area of the first Baige landslide was unstable again, causing the second landslide. It has been studied by many researchers, Xu et al. (2018) and Deng et al. (2019) analysed the formation mechanism and process of two landslides, and found that the site is in the Jinsha River suture zone, where the influence of multiple tectonic movements provides a complicated regional tectonic profile; the main fault structures trend NW, within the Jiangda-Bolo-Jinshajiang fault zone (Fig.2). Ouyang et al. (2019), Fan et al. (2019a) and Wang et al. (2020c) carried out numerical simulation analysis of Baige landslide. In this study, only the "10.10" Baige landslide was studied. The landslide can be divided into four areas, namely, shear, main slip, blocking, and deposition, with maximum and average thicknesses of 80 and 50 m (Fig. 1c). We used terrain data from Ouyang et al. (2019), comprising a 10 m resolution pre-landslide Digital Elevation Model (DEM) from 2017, and a 5 m resolution post-slide DEM obtained through Unmanned Aerial Vehicle (UAV) photogrammetry in 2018 from field investigation. Based on DEM differencing, total landslide volume was calculated as 1.96×10^7 m^3. The altitude range of the initiation zone is 3523 to 3730 m. Most of the rock mass that collapsed from the steep back wall accumulated at an elevation of 3100 to 3300 m, in an area of gentle slope angle from 20 to 25°".

C3: l.188 -200: As stated in your response R12, you have two criteria to evaluate the quality of seismic signal: 1) check that seismic energy lies between the NLNM and NLNM, 2) check the SNR of the signal associated to the landslide. If I'm not wrong, you only mention point 1 at this point in the manuscript (it is explained latter), but the SNR is also important and I would mention it, at least briefly.

R3: Thank you very much for the useful suggestion. In section 4.2 including Table 3 we provided a detailed description of SNR for seismic traces and a criterion to select seismic traces based on the SNR. At the same time, we also added a brief description of SNR at this place.

Add the following sentence to the end of the paragraph:

"··· good seismic observation environment. Before carrying out the dynamic inversion, we will calculate the SNR for each seismic trace and use it to determine if the trace will be used in the inversion, about which a detailed description can be found in section 4.2 Dynamic inversion of landslide."

C4: l.328: Following my previous comment C17, it is still not clear to me how you adapt your simulation parameters if you criteria (CSI>0.6 or criteria on \delta) are not met. For instance, if for one simulation CSI=0.5, how do you choose the new values of \mu_i, C_u and T_u to be tested?

R4: We thank the reviewer for the comments. Previous studies have shown that in the discrete element method, the deposition area of landslide is obviously affected by the parameters of bond strength and friction coefficient (An et al., 2020). These two types of parameters correspond to breaking displacement x_b, initial shear resistance F_{s0} and intergranular friction coefficient μ_p in MatDEM. C_u and T_u are related to F_{s0} and x_b. F_{s0} is equivalent to the bond strength. If CSI > 0.6 is not met, new values of μ_i, C_u and T_u are adjusted according to some generally accepted rules in previous literature (For example, the smaller the friction coefficient is, the larger the deposition area is; The larger F_{s0} is, the less likely the particles are to break at the beginning, the smaller the displacement and the smaller the deposition area). So, if CSI = 0.5, first determine whether the particle deposition area is too large or too small, too small by reducing the friction coefficient, reduce C_u and T_u to increase CSI. When it is too large, the CSI is reduced by increasing the friction coefficient and increasing C_u and T_u.

Reference:

An, H. C., Ouyang, C. J., Zhao, C., and Zhao, W.: Landslide dynamic process and par ameter sensitivity analysis by discrete element method: the case of Turnoff Creek rock avalanche, J. Mt. Sci., 17, 1581-1595, https://doi.org/10.1007/s11629020-5993-7, 202 0.

C5: l.337-338: Following my previous comment C24, the definition of the variance is, in statistics, the average of the square difference between values and their mean. So if I understand well your definition, what you call S2 in the manuscript is not a variance, it is a square residue.

R5: We agree with the reviewer, and now we have modified "variance" to "square residue".

C6: l.409-411: "high SNR of the N component of the landslide signal and low SNR of the E component". At l.397-398, don't you say that "E" has a high SNR, and "N" a

lower SNR? Or if the latter sentence refers to the end of the signal, it should be stated more explicitly.

R6: We thank the reviewer for the comments. As the reviewers said, the latter sentence refers to the end of the signal. So, we have now modified this sentence to make it clearer. As follows: "This feature is consistent with the high SNR of the N component at the end of the landslide signal and low SNR of the E component".

C7: l.432: you say that Fig 6 displays acceleration curves (this is also what the caption says), but the unit of y-axis is that of a velocity.

R7: We are truly sorry for the acceleration curves description in the original text. Fig 6 displays velocity curves, we have modified the caption as follows: "Fig. 6. Time-domain velocity signal (E\N\V direction) of the seismic generated...".

C8: l.435-436: I'm not sure to understand your interpretation. If in Fig 6 you display acceleration, and not velocity, shouldn't acceleration changes be correlated to a change in sign, rather than to maxima (as for e.g. your point 4). When acceleration is positive, the velocity increases and the landslide accelerates, when acceleration is negative the velocity decreases and the landslide decelerates.

R8: We are sorry that there is an error here. Figure 6 is the time-domain velocity curve, and we have now modified the relevant descriptions.

C9: l.488: If I'm correct, that is the first mention in the manuscript of the second landslide that occurred on October 12. The latter should be mentioned when you present the Baige landslide.

R9: We are sorry that we made a mistake here, we compared the signal of the flood outbreak on October 12, 2018, and there was no landslide event. We added an introduction to the flood in the "Study area" paragraph, please refer to the answer to C2.

At the same time, we have modified the error here as follows: "...of the outburst flood signal on October 12, 2018 (Xu et al., 2018)".

C10: l.609-611: Are these masses consistent with the volume estimated from DEM analysis? I would add a comment on that matter.

R10: Thank you very much for the constructive advice. We added some descriptions in the revised manuscript to compare the DEM-derived sliding volume and the volumes estimated from dynamic inversion and empirical relationships.

"Using the empirical relationships of Chao et al. (2016) and Ekström and Stark (2013), the maximum inverted force of 1.37×10^{11} N gives estimated sliding masses of 5.5×10^{10}

kg and 7.4×10^{10} kg, respectively, which are about 1.32 and 1.77 times of our estimation of about 4.2×10^{10} kg from landslide force inversion. We further use a density of 2.4×10^{3} kg/m^3 (Zhang et al., 2019) to estimate the volumes corresponding to these masses. The results are 1.75×10^{7}, 2.29×10^{7}, and 3.08×10^{7} m^3, accounting for 89%, 117%, and 157% of that derived from DEM differences. All estimated volumes are consistent with the DEM-derived volume in general, only that the estimates from empirical relationships are slightly larger. This is not surprising as we used a different frequency band in our inversion (0.006–0.2 Hz) than the two studies (e.g., Ekström and Stark (2013) used the frequency band 0.0067 – 0.0286 Hz (35–150 s). Previous work has shown that, for the same event, use of different frequency bands produces landslide force histories of different amplitudes (Hibert et al., 2014; Moore et al., 2017; Zhang et al., 2020b). As a comparison, we performed inversion in the frequency band 0.0067 – 0.0286 Hz, which gave a maximum force of 1.03×10^{11} N and sliding mass estimates of 4.20×10^{10} kg and 5.60×10^{10} kg that are more consistent with our estimation. The newly estimated volumes from empirical relationships are also closer to the DEM-derived volume, accounting for 89% and 119%, respectively. Since the frequency bands that we used in the two inversions have similar lower cutoff frequencies, both of which include the duration of sliding (Gualtieri and Ekström, 2018; Toney and Allstadt, 2021), the kinematic parameters estimated from both inversion results are essentially similar in their characterization of overall landslide motion. …

References

Gualtieri, L., and Ekström, G.: Broad-band seismic analysis and modeling of the 2015 Taan Fjord, Alaska landslide using Instaseis, Geophys. J. Int., 213, 1912–1923, https://doi.org/10.1093/gji/ggy086, 2018.

Toney, L., Allstadt, K.E.: lsforce: A Python-Based Single-Force Seismic Inversion Framework for Massive Landslides. Seismol. Res. Lett. 92, 2610–2626. https://doi.org/10.1785/0220210004, 2021.

Specific comments

C1: l.124: “The thin-layer model, it is based...” -> “The thin-layer models are based…”

R1: Thank you for your advice. We have modified to “The thin-layer models are based…”

C2: l134 – 139: That is a single sentence, it is too long. Besides, I think there is problem in the sentence. In particular “used to quality” is not a correct expression I believe.

R2: We thank the reviewer for the comments. We shortened this sentence to make it clearer. The modification is as follows: “In this study, we use long period seismic signal to obtain the dynamic characteristics of Baige landslide, China, which occurred on

October 10, 2018 (termed as the “10.10” event). Combined with the inversion results, the landslide process was reconstructed by numerical simulation. Through seismic signal analysis, landslide dynamic inversion and numerical simulation, combined with the post-event field investigation, we try to provide an improved characterization of the landslide movement process”.

C3: l.161: By DOM, do you mean Orthophotograph? If yes, you could simply use “orthophotograph”. Alternatively, explain what “DOM” means in the main body of the article (maybe it already is and I missed it).

R3: Thank you for your comment. We have added the explain of “DOM” as “Digital Orthophoto Map (DOM)”.

C4: l.200: The lines for the NHNM and NLNM are red an green in the new version of the figure, not white as stated in the legend.

R4: Thank you for your reminder. We have modified the legend as “Red line in the PSD image is NHNM and green line is NLNM”.

C5: l.263: The notation “10.10” is used in the introduction, but repeated until l.263. To improve the readability of the manuscript, I would use it also in Section 2, where you present the event.

R5: Thank you for pointing this out. We have now used this notation in the second section as follows: “A massive landslide occurred at Baige, on the eastern Qinghai-Tibetan Plateau, China, on October 10, 2018 (termed the “10.10” event)”.

C6: l.289-290: “cutting particles”: what do you mean?

R6: Thank you for your comments. This sentence is inaccurate and has been revised to “The landslide area is constructed by particles accumulated in the cube model box using the topography cutting of pre- and post- landslide”.

C7: l.293: When you first apply gravity, are particles re-arranged? Do you have compaction, or are particles already compacted?

R7: Yes, when gravity is applied, the position of the particles will change, which can be understood as re-arranged. However, the particle number is unchanged. The process of applying gravity is to performed a natural deposition process the particles, not compaction.

C8: l.300: I would add a reference to Fig. 5 before you start explaining the method, so that the reader can refer to it while reading.

R8: Thank you for your constructive comments. As instructed, we have now added a reference as follows: "As shown in the flow chart of Fig. 5, we used the…".

C9: l.304 – 305: "the micro-parameters … can be obtained". There is problem in the sentence, it is not clear how and from what the parameters can be obtained. Besides, you could remove capital letters I think.

R9: Thank you for your comments. We obtain microscopic parameters, such as normal stiffness, tangential stiffness, fracture displacement, initial shear force and particle friction coefficient, which are calculated by the macro-micro conversion formula proposed by Liu et al. (2013) (see Appendix 1 for details) on the basis of obtaining the initial macroscopic parameters, such as Young modulus, Poisson's ratio, tensile strength, compressive strength and internal friction coefficient. And we have modified this sentence and removed the capital letters. As follows:

"Initial macro parameter values, such as Young modulus, Poisson's ratio, were based on results of laboratory tests on Baige landslide materials from Zhou et al. (2019), the micro parameters, such as normal stiffness, shear stiffness, breaking displacement, initial shear resistance, of DEM input can be obtained by using the macro and micro conversion equations proposed by Liu et al. (2013) (see Appendix 1 for details)".

C10: l.399: Shouldn't it be "E" and "V", instead of "E" and "N"?

R10: Thank you for your comments. It should be "E" and "N", because we talk about a lateral motion feature.

C11: l.407: "and from north-south limited to east-west limited", there is problem in the formulation I think.

R11: Thank you for pointing this out. Considering other comments, we have deleted this sentence.

C12: l.406-407: "During the…limited", I would actually delete this sentence, the following one is much clearer.

R12: Thanks a lot. We have deleted this sentence.

C13: l.418, Fig 6: You should say in the caption what numbers 1 to 7 refer to.

R13: Thank you for the useful comment. We have now added it in the caption as follows: "Time-domain velocity signal (E\N\V direction) of the seismic generated by the Baige landslide at GZI seismic station, showing a relative high signal-to-noise ratio visually but different respectively (①~⑦ refer to the characteristic stage of the Baige landslide)".

C14: l.440 and forward: I would say "landslide duration" instead of "landslide time".

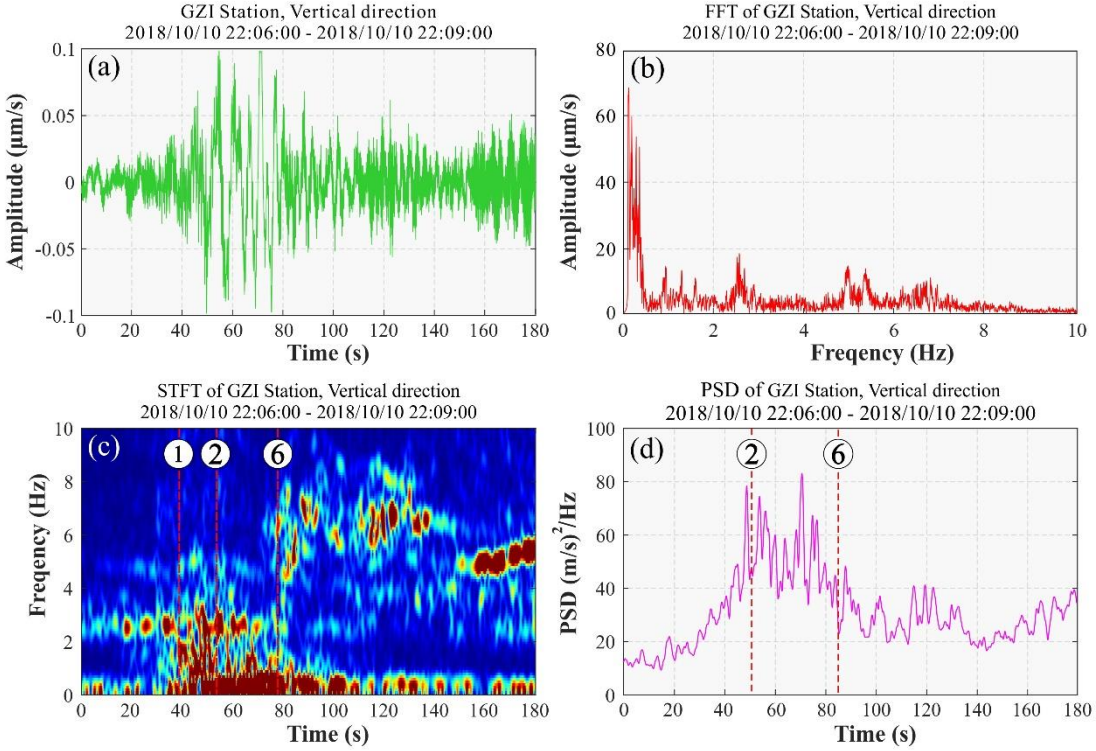
R14: Thank you for your comments. We have modified this sentence as follows: "All these make the duration of the landslide derived from the original seismic signal would be lagged and longer, compared to the real time. A more accurate landslide duration can be determined by landslide force history inversion as it eliminates the propagation effect".

C15: l.449: "is to help" -> "helps"

R15: Thank you for your advice. We have revised it, as follows: "The analysis of the velocity curve recorded at seismic stations helps understand the ···".

C16: l.470-471: Specify the frequency bandwidth use to compute the PSD in Fig. 7d.

R16: Thank you for your comments. We have modified the Fig. 7d. And the frequency bandwidth uses to compute the PSD is 0~8 Hz.



C17: l.613: “for the same event” -> “for a given event” (otherwise we may think all previous studies refer to the Baige landslide).

R17: Thank you for pointing this out. We have modified it, as follows: “Previous work has shown that, for a given event, ···”.

C18: l.644: “even” -> “even if”

R18: Thank you for the comment. We have changed “even” to “even if”.

C19: l.752-753: “Concentrating … ambiguity”, there seems to be a problem in this part of the sentence. What do you mean by concentrating?

R19: In the numerical simulation of landslide, there are multiple solutions due to the numerical simulation itself. If we use the results of dynamic parameter inversion to constrain, the reliability of numerical simulation is improved. Constraint method: The key parameters of numerical simulation are adjusted, and the force, acceleration curve and velocity curve of numerical simulation are compared with the inversion results until the numerical simulation results are similar to the inversion results. We did not express it accurately enough, and we have now revised “concentrating” to “constraining”.

C20: l.772: “Each of the three methods”, it is not clear what these 3 methods are.

R20: Thank you for the comment. “Each of the three methods” refer to the seismic signal analysis, landslide dynamic inversion and numerical simulation explained in the first three paragraphs of this section, and are also introduced in sections 3.1, 3.2 and 3.3 of the Methodology section.

C21: l.777: “We use” -> “We used”, to be consistent with the next sentences where you use the past.

R21: Thanks a lot. We have changed “We use” to “We used”.

C22: l.778: “to provides” -> “to provide”

R22: Thank you for the comment. We have changed “to provides” to “to provide”.

C23: l.782 – 783: “With the assessment of numerical simulation…” -> “After calibrating the parameters of the numerical models, the dynamic process of the “10.10” Baige landslide was analysed”.

R23: Thanks a lot. We have modified it, as follows: “After calibrating the parameters of the numerical models, the dynamic process of the “10.10” Baige landslide was analysed”.