Reply to Reviewer Comments

(C and R denotes comment and reply, respectively)

Reviewer 1:

General comments:

C1: I enjoy reading this manuscript. It proposes a new 'combined' approach to back-analyze seismic signals of a landslide process. The idea is great!

The methodology is technically sound. The proposed simulation process is deemed logical and the results were properly verified and discussed.

However, the writing (English language) must be carefully examined/fixed to make it easy to read and understand.

From places to places, I feel many descriptions are somehow redundant, they are telling the same idea. Please check the whole text again.

I would like to make sure that readers can apply the simulation techniques to their own landslide cases. Therefore, I suggest the DemMat, inversed and synthetic codes shall be shared to readers and are accessible to readers.

R1: Thank you for spending the time to review and assess our manuscript. As instructed, we have now supplemented the information according to the comments received from the expert reviewer. At the same time, we have also deleted the unnecessary materials pointed out by the reviewer. Please see our detailed point-by-point reply to the comments below.

Specific comments:

C1: Abstract is lengthy. Please re-write for concise and clarity.

R1: Thank you for your constructive comments. Combining the comments from Reviewer 2, the abstract is shortened as below:

Landslides present a significant hazard for humans, but continuous landslide monitoring is not yet possible due to their unpredictability. In recent years, numerical simulation and seismic inversion method have been used to provide valuable data for understanding the entire process of landslide movement. However, each method has shortcomings. Dynamic inversion based on long-period seismic signals gives the force-time history of landslide using empirical Green's function, but lack of detailed flowing characteristics of the hazards. Numerical simulation can simulate the entire movement process, but results are strongly influenced by choice of modelling parameters. Therefore, developing a method for combining those two techniques has become a focus for research in recent years. In this study, we develop such a protocol based on analysis of the 2018 Baige landslide in China. Seismic signal inversion results are used to constrain and optimize the numerical simulation. We apply the procedure to the Baige event and, combined with field/geological survey, show it provides a comprehensive and accurate method for dynamic process reconstruction. We found that the Baige landslide was triggered by detachment of the weathered layer, with severe top fault segmentation. The landslide process comprised four stages: initiation, main slip, blocking, and deposition. Multi-method mutual verification effectively reduces the inherent drawbacks of each method, and multi-method joint analysis improves the rationality and reliability of the results. The approach outlined in this study could help better understand the landslide dynamic process.

C2: Line 31: Using “low frequency curve" is not clear. What curve? Motion curve or others?

R2: Thank you for the useful comment. What we would like to express here is the low-frequency signal of dynamic parameter changes during the evolution of debris flow. We are sorry that there are some problems with our expression, which has been revised. We have now deleted "curve of".

C3: Line 38: … obtain the best numerical “simulations”?

R3: Thank you for your constructive comments. This sentence is inaccurate and has been revised to “Seismic signal inversion results are used to constrain and optimize the numerical simulation”.

C4: Line 45~46: “The approach outlined in this study could be used to support hazard prevention and control in sensitive areas.” I don't think this method can support hazard prevention and control landslide hazard. It just one kind of back-calculation to understand the landslide process. What's happened has happened, so how can we prevent and control the landslide? Considering write something else that is appropriate.

R4: Thank you for your advice. We totally agree with you. We have modified this sentence to “The approach outlined in this study could help better understand the landslide dynamic process.” in manuscript.

C5: Line 137: Explain how to obtain the “Probabilistic power spectral density”, what is the technique or provide references. How you identify the ‘background noise level of the seismic station” from Fig. 3. And, how to apply it next? And why this is important?

R5: Landslide force history inversion uses long-period seismic waveforms and thus requires that the ambient noise at periods of tens of seconds should be at a low level in the study area.

We provided references (e.g., McNamara and Buland, 2004; Peterson, 1993) for the PSD calculation. Fig. 3 provided the new high noise model (NHNM) and new low noise model (NLNM) derived by Peterson (1993) as references. The PSD of the vertical component for station BTA (Fig. 3) reveals that the main seismic energy is distributed between the reference models, indicating that the study area has a relatively good seismic observation environment.

The modified version is shown in below:

"We selected broadband seismic signals from seven seismic stations that are distributed around the landslide with adequate azimuth coverage (Fig. 1d) to carry out the analysis. Landslide force history inversion uses long-period seismic waveforms and thus requires that the ambient noise at periods of tens of seconds should be at a low level in the study area. We used the probabilistic power spectral density (PSD) technique (McNamara and Buland, 2004) to characterize the background seismic noise. As illustrated by the PSD of the vertical component for seismic station BTA (Fig. 3), the main seismic energy is distributed between the new high noise model (NHNM) and the new low noise model (NLNM) (Peterson, 1993), indicating that the study area has a relatively good seismic observation environment."

Reference:

McNamara, D. E., Buland, R. P. 2004. Ambient Noise Levels in the Continental United States. Bull. Seismol. Soc. Am. 94, 1517–1527. https://doi.org/10.1785/012003001.

Peterson, J. R. 1993. Observations and modeling of seismic background noise, U.S. Geological Survey Open-File Report 93-322. https://doi.org/10.3133/ofr93322.

C6: Line 147: What kind of "joint time-frequency domain transform" was used? Just delete 'joint'?

R6: Thank you for your constructive comments. We did not express it accurately enough. We have revised the sentence to remove the "joint".

C7: Line 150: "… that corresponds to a specific moment…" What kind of 'specific moment'?

R7: Thank you for the useful comment. This refers to all seismic, i.e., the source of the source that produces the signal.

C8: Line 168: "… the records were resampled to 0.2 s." What does this mean? You mean 5 Hz sampling rate?

R8: Yes, the records were resampled at a sampling rate of 5 Hz.

C9: Line 182: "… and 9+ Xs" Is the 9+ a typo?

R9: "…9+ X_s is the tangential displacement" This should be a clerical error. We have modified to "K_s is the tangential stiffness; and X_s is the tangential displacement".

C10: Fig. 4: Do you need to predefine the properties of the "slide bed elements"?

R10:

Thank you for your constructive comments. In this study, the properties of "slide bed elements" are not defined separately but adopt the same value as "source area elements". This is because the soil types in the landslide area are the same. The "slide bed elements" are equivalent to a certain thickness of soil layer under the "source area elements". We have added a reference at here, as follows:

Fig. 4. Schematics showing properties of landslide particles and discrete element model. (a) Linear elastic bonded model; (b) Discrete element model of the Baige landslide (Fan et al., 2019a).

Reference:

Fan, X., Yang, F., Subramanian, S. S., Xu, Q., Feng, Z., Mavrouli, O., Peng, M., Ouyang, C., Jansen, D., and Huang, R.: Prediction of a multi-hazard chain by an integrated numerical simulation approach: the Baige landslide, Jinsha River, China, Landslides, 17, 147-164, http://doi.org/10.1007/s10346-019-01313-5, 2019a.

C11: Line 206: How about "We used a simulation block of 2270×1980×1680 m, with …"?

R11: Thank you for the useful comment. We want to express the scale in x, y, z three direction of landslide model is 2270 m, 1980 m, 1680 m. we have changed "simulation area" to "simulation block".

C12: Line 207: Is this "cells" means "elements"? Is there any other better word?

R12: Thank you for the useful comment. We have changed the "cells" to "elements" in line 242.

C13: Line 218: What are the macro and micro conversion formula? Are they important?

R13: Thank you for your constructive comments. "macro and micro conversion formula" was an experience formula proposed by Liu et al. 2013, its build a bridge from macro parameters, such as E, v, C_u, T_u, μ_i to micro parameters K_n, K_s, F_{s0} X_b, μ_p。 This formula used to obtain initial parameters of elements, initial parameters still need to adjusted to obtain reasonable simulation result.

We have supplied the reference in manuscript in Line 244-245, and added the macro and micro conversion formula in the Appendix 1, as follows:

$$K_n = \frac{E}{\sqrt{3(1-2v)(1+v)}} \tag{A1}$$

$$K_s = \frac{E(1-4v)}{\sqrt{3(1-2v)(1+v)}} \tag{A2}$$

$$X_b = \frac{2K_n + K_s}{2\sqrt{3}K_n(K_n + K_s)} T_u d \tag{A3}$$

$$F_{s0} = (\frac{1}{4} - \frac{\sqrt{3}}{4}\mu_p) C_u d \tag{A4}$$

$$\mu_p = \frac{-3\sqrt{3} + \sqrt{3}I}{3 + 3I}, I = [(1 + \mu_i)^{0.5} + \mu_i]^2 \tag{A5}$$

where Kn and Ks are the normal and shear stiffness of the particle, respectively; E is Young's modulus; v is Poisson's ratio; X_b is breaking displacement; T_u is uniaxial tensile strength; d is particle diameter; F_{s0} is initial shear resistance; μ_p is intergranular friction coefficient; C_u is uniaxial compressive strength; μ_i is internal friction coefficient.

C14: Line 219: Why 40% is fine? Any prove?

R14: Thank you for the useful comment. It is generally accepted that there is a significant reduction in strength with increasing specimen size (Darlington et al., 2011). Hoek (2000) suggests this reduction in strength is due to the increased probability that failure of rock grains will occur as the specimen size increases. Therefore, elastic modulus in laboratory tests is usually higher than those in large-scale rock masses in the field.

As for the selected value in this study, it is related to the shape and volume of the selected samples. With the volume of test samples increases, the strength may decrease for 50%. As reported by Pratt et al. (1972), the field tests results are only 30%~70% of the laboratory test. This reduction may relate to the lithology and weathering.

Regarding the numerical simulation results of the landslide, they are mainly related to the size of the spherical unit. Less quantitative research results on the differences between the strength characteristic values and the results of indoor tests and field measurements at the numerical simulation scale have been reported. Liu et al. (2019) used MatDEM to simulate Xinmo landslide, set Young's modulus and strength to about 40% of the test value, and an excellent simulation result is got when using this threshold. In our study, the landslide scales, characters element radius, and even the lithology are similar to this work, therefore, we take reference to Liu et al (2019), which carried out the DEM simulation on the Xinmo landslide, and the threshold 40% of the laboratory test value is used in our simulation. We have supplied the reference in manuscript.

Reference:

Darlington, W.J., Ranjith, P.G., and Choi, S.K.: The Effect of Specimen Size on Strength and Other Properties in Laboratory Testing of Rock and Rock-Like Cementitious Brittle Materials, Rock Mech Rock Eng, 44, 513, https://doi.org/10.1007/s00603-011-0161-6, 2011.

Heuze, F.E.: Scale effects in the determination of rock mass strength and deformability, Rock Mechanics, 12, 167–192, https://doi.org/10.1007/BF01251024,1980.

Hoek E (2000) Rock engineering course notes by Evert Hoek. http://www.rocscience.com/education/hoeks_corner.

Liu, C., Fan, X., Zhu, C., and Shi, B.: Discrete element modeling and simulation of 3-Dimensional large-scale landslide-Taking Xinmocun landslide as an example, J. Eng. Geol, 27, 1362-1370, https://doi.org/10.13544/j.cnki.jeg.2018-234, 2019. (In Chinese)

Pratt, H. R., et al. (1972): The Effect of Specimen Size on the Mechanical Properties of Unjointed Diorite, Int. J. Rock Mechanics and Mining Science, V. 9, pp. 513--529.

C15: Fig. 5: Why 35 and 10 % of delta is reasonable?

R15: Thank you for the useful comment. Traditional back-analysis of landslide usually use the final deposition accuracy to validate the results of numerical simulation due to the lack of continuous on-site monitoring during the whole process (Sassa et al., 2010; Ouyang et al.,2016; Li et al., 2022). The critical success index proposed in recent year (Mergili et al. 2017), considering both accuracy and error, has been introduced into landslide back analysis with application (An et al. 2021). However, due to lack of continuous monitoring, the same deposition pattern may be caused by different dynamical processes, which blind the dynamic inversion of landslide using numerical simulation. Fortunately, the seismic signal generated by landslide can record the dynamic process of landslide such as force-time history.

The calculation efficiency and accuracy are considered as two main issues in numerical simulation. Landslide simulation using DEM may produce a saltation of particles and cause errors. In this study, we selected 2 key indicators, peak displacement Dmax and time when peak velocity achieved Tvmax, as two key indicators to constrain the simulation. It should be noted that in previous landslide simulations, the maximum distance of runout and the actual error usually between 20% and 30 % (Ouyang et al.,2016； Scaringi et al., 2018). Therefore, two parameters that controlling the landslide movement process, are chosen a threshold of 10%. The other two parameters, peak velocity Vmax and landslide duration T, less important compared with first two, have certain reference value for describing the process of landslide movement. Here two reasons are considered for choosing a relatively large threshold of 35%. First, the method of inverting the landslide velocity can be affected by topography change and entrainment process especially in complex mountain areas. Second, the starting point of the actual landslide movement may not be so clear, and even after the deposition is completed, there will still be local small scale of landslides which produce a continuous seismic signal. Therefore, compared with actual observation (e.g., CSI), they could be given a higher degree of tolerance.

It should be noted that whether it is 10% or 35%, it is not yet a generally accepted threshold. In this study, the simulation results obtained beyond the above thresholds will have large difference compared with the actual deposition. Therefore, the above thresholds should be adjusted for the purpose of the study, especially depending on the case of the study or the accuracy of the input terrain data. However, less threshold means more times of try and error, which will dramatically increase the time of calibration. Therefore, in considering the calculation efficiency, we use threshold of 10% or 35% for those four parameters.

Reference:

Li, Y., Chen, J., Li, Z., et al. (2022). Comprehensive analysis of a paleo-landslide damming event on the upper reach of the Jinsha River, SE Tibetan Plateau. Bulletin of Engineering Geology and the Environment, 81(8). doi:10.1007/s10064-022-02791-z

Ouyang, C., Zhou, K., Xu, Q., Yin, J., Peng, D., Wang, D., & Li, W. (2016). Dynamic analysis and numerical modeling of the 2015 catastrophic landslide of the construction waste landfill at Guangming, Shenzhen, China. Landslides, 14(2), 705-718. doi:10.1007/s10346-016-0764-9

Sassa, K., Nagai, O., Solidum, R., Yamazaki, Y., & Ohta, H. (2010). An integrated model simulating the initiation and motion of earthquake and rain induced rapid landslides and its application to the 2006 Leyte landslide. Landslides, 7(3), 219-236. doi:10.1007/s10346-010-0230-z

An, H. C, Ouyang, C. J, Zhou, S.: Dynamic process analysis of the Baige landslide by the combination of DEM and long-period seismic waves., Landslides, 18, 1625-1639, https://doi.org/10.1007/s10346-020-01595-0, 2021.

Mergili, M., Emmer, A., Juřicová A., Cochachin, A., Fischer, J. T., Huggel, C., and Pudasaini, S. P.: How well can we simulate complex hydro-geomorphic process chains? The 2012 multi-lake outburst flood in the Santa Cruz Valley (Cordillera Blanca, Perú)., Earth Surf Process Landf, 43, 1373-1389., https://doi.org/10.1002/esp.4318, 2017.

Scaringi, G., Fan, X. M., Xu, Q., Liu, C., Ouyang, C. J., Domenech, G., . . . Dai, L. X. (2018). Some considerations on the use of numerical methods to simulate past landslides and possible new failures: the case of the recent Xinmo landslide (Sichuan, China). Landslides, 15(7), 1359-1375. doi:10.1007/s10346-018-0953-9.

C16: Fig. 5: Is CSI 0.6 is a commonly acceptable value? Any references?

R16: Thank you for your constructive comments. An et al. (2021) conducted 25 simulations by changing the parameters such as static friction coefficient, thermal weakening friction coefficient and normal bond strength. The results showed that only 8 cases acceptable had CSI > 0.6 with the highest CSI of 0.83. Among the 15 groups of results simulated by Mergili et al. (2017), the maximum CSI is chosen as 0.59. In addition to the CSI value, this study also needs to further adjust the simulation parameters according to the dynamic characteristics. Therefore, the CSI value should not be set too high to avoid low simulation efficiency. Therefore, CSI > 0.6 is chosen in this study. We have supplied the reason and reference in manuscript.

Reference:

An, H. C, Ouyang, C. J, Zhou, S.: Dynamic process analysis of the Baige landslide by the combination of DEM and long-period seismic waves, Landslides, 18, 1625-1639, https://doi.org/10.1007/s10346-020-01595-0, 2021.

Mergili, M., Fischer, J. T., Krenn, J., and Pudasaini, S. P.: r. avaflow v1, an advanced open-source computational framework for the propagation and interaction of two-phase mass flows, Geosci. Model Dev, 10, 553-569, https://doi.org/10.5194/gmd-10-553-2017, 2017.

C17: Fig. 5: After the adjustment of Intergranular friction coefficient *μp* and damping coefficient C, don't you need to check if CSI>0.6 again? The CSI is possible smaller than 0.6, isn't it?

R17: Thank you for your advice, After the adjustment of intergranular friction coefficient and damping coefficient C, we check if CSI>0.6 at first, then check the other indices. We have now adjusted the Fig.5.

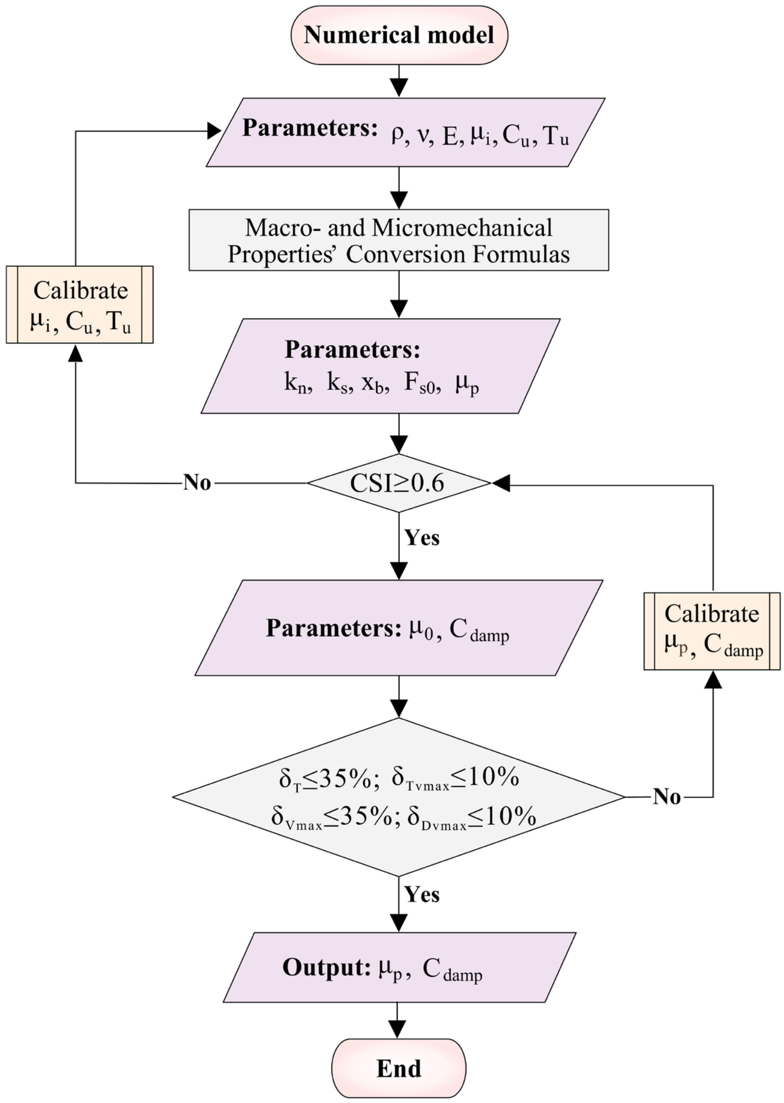


Fig. 5. Flowchart of the method of discrete element parameter adjustment based on seismic signal inversion.

C18: Line 252: "post-event geological survey showed sliding was mainly in a south-east-to-south direction" By observing Fig. 3, it seems that the sliding was almost in an eastward direction. Isn't it?

R18: That is what we would like to say, and we made it clear accordingly, as follows:

"The SNR of the vertical (V) and east (E) components is relative higher, compared with north (N) component, roughly reflecting the main slide direction of landslide is E and N. Post-event geological survey showed sliding was mainly in south-east-to-south, approximately eastwards."

C19: Fig. 6 shows "showing signal-to-noise ratio of the low-frequency components"? Explain how to identify high and low SNR. From Fig. 6 I feel they are approximately the same SNR in the E\N\V direction, even in the low frequency range. Therefore, I treat Line 249~259 is a kind of qualitatively discussion.

R19: Thanks a lot. The legend in Figure 6 "showing signal-to-noise ratio of the low-frequency components (E\N\V direction)." This expression is somewhat inaccurate. To be precise, it reflects the signal-to-noise ratio of the entire data band, especially the distinction between high-frequency and high-frequency signal-to-noise ratios. From the three graphs, the high-frequency signal-to-noise ratios of E and V are relatively high, and N is relatively high. lower. We have now corrected Lines 298~301 as:

"The SNR of the vertical (V) and east (E) components are relative higher, compared with north (N) component, roughly reflecting the main slide direction of landslide is E and N. Post-event geological survey showed sliding was mainly in south-east-to-south, approximately eastwards."

C20: Line 272: how about "The time domain velocity recorded at …"?

R20: This represents the curve formed by the acceleration of the GZI station at each moment. The signal analysis in this manuscript involves the frequency domain and the time domain, where the time domain is used to distinguish it from the frequency.

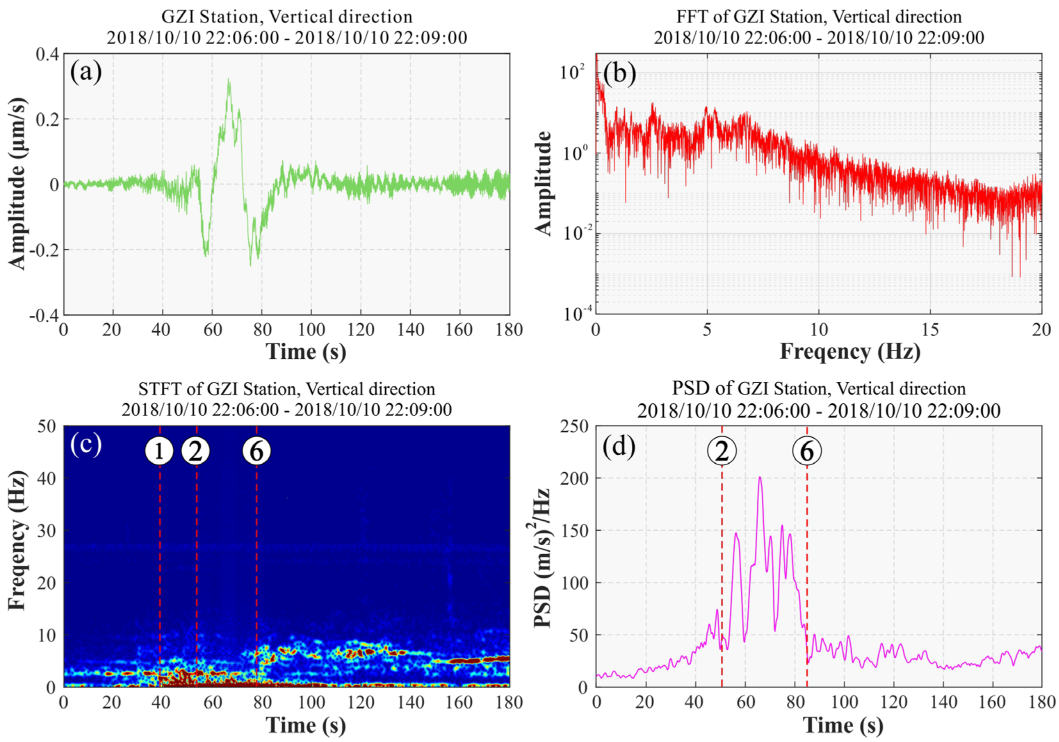
C21: Line 279: Although I get what you want to say, please re-write the sentences: "… and the signal may also be affected by superimposition of vertical and horizontal waves, which makes the end time lag. So, the critical moments of the landslide derived from the original seismic signal would be lagged, and the duration too long."

R21: We have made changes based on the reviewer's comments as follows:

"…what's more, the signal is mixed by longitudinal wave that stack with transverse wave, which makes the ending time picked by seismic signal much latter than the actual time. All these make the time of the landslide derived from the original seismic signal would be lagged and longer, compared to the real time."

C22: Fig. 7: The time axis appears redundant times? e.g., 22:06 22:06 ...

R22: We have modified Fig. 7 as follows :



C23: Fig. 7: You can show the Fig. 7 b in log-scale for better low frequency resolution.

R23: Thank you for the useful comment. We have modified Fig. 7b as responded in C22.

C24: Fig. 7: Why choose vertical component (V) for analysis? Isn't that the GZI east (E) component has a lower SNR, with less noise?

R24: This is because the V component has the highest signal-to-noise ratio, and the inversion of V component can reflect the force on main sliding direction and normal direction, and its analysis accuracy is relatively reliable.

C25: Line 300: Change to "… with the time domain stages (as in Table 2), …"

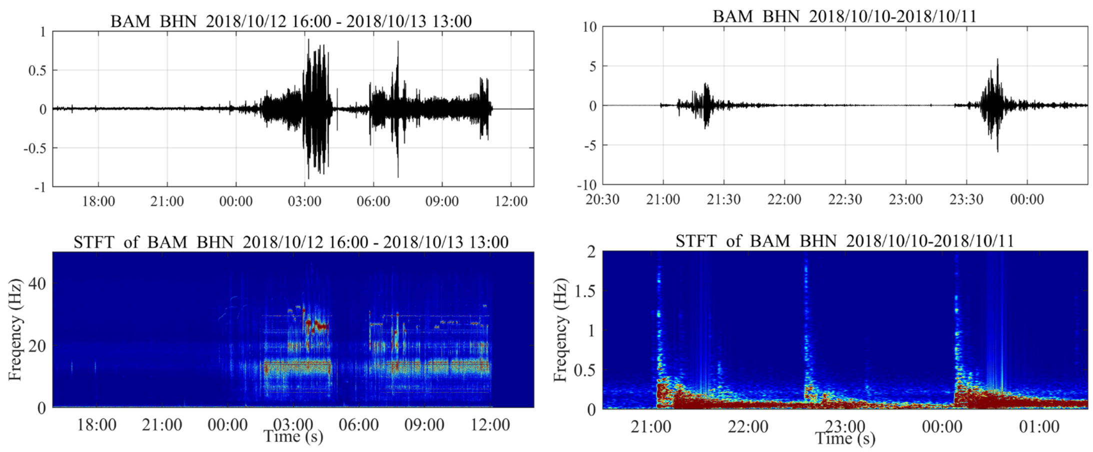
R25: We thank the reviewer for this comment. We have modified this sentence as follows:

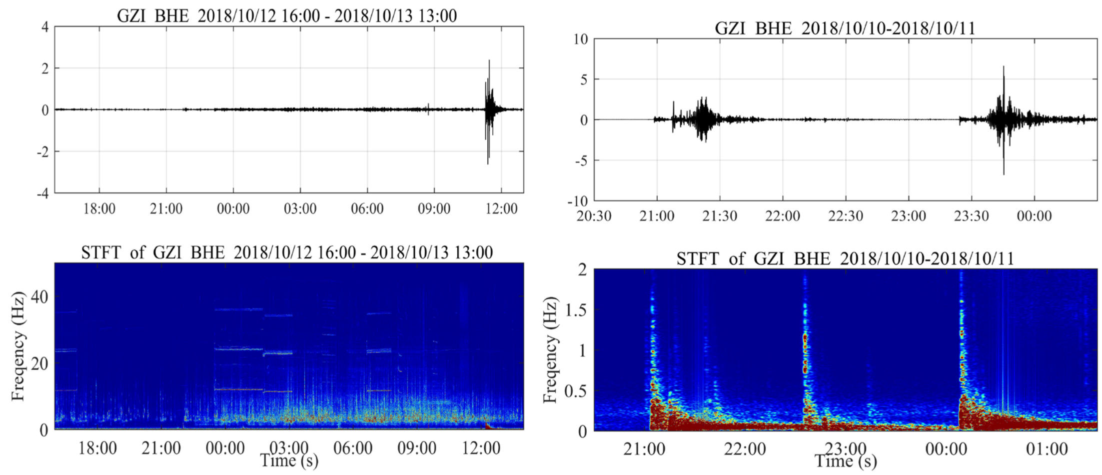
"Comparing with the time domain stages (as in Table 2), the first PSD stage corresponds to the first acceleration….."

C26: Line 309: "also, there is a clear difference from the outburst flood signal on October 12, 2018." Can you present a figure for showing the differences between outburst flood on Oct. 12?

R26: According to the statistics in our previous research, when water is involved, that is, debris flow or high-density flow, the frequency of the seismic signal is relatively high, and its main frequency range can reach 3~50Hz, and more than 5Hz (Yan, et al, 2021; Yan, et al, 2017). "Clear difference" refers to the frequency of the seismic signal of the flood discharge event after the second landslide in Baige, and the difference between the curve mentality and the current landslide; because there are relatively many studies on the seismic signal of floods and debris flows, so this time the seismic signal for the second flood event was not added. In the revised manuscript, we have added a description of the second landslide seismic signal frequency information. We changed the paragraph of the original Line306-310 as follows:

According to Yan et al (2021), the frequency of landslide hazard seismic signals is usually low (0~5Hz), and the morphology in the time-frequency domain and time domain presents single-peak or double-peak characteristics, while the frequency of flood or high-density flow seismic signals is usually high (5~50Hz), and the morphology in the time-frequency domain and time domain mostly presents the characteristics of flat. Combined with this landslide seismic signal has relatively low frequency (0–1 Hz) and the single-peak feature in time and time-frequency characteristics, apparently different from the spectrum (main frequency :15~30Hz) of the outburst flood signal triggered by the second landslide on October 12, 2018 (An et al, 2021). So, we think there was no flood discharge during the landslide process.





Reference:

Yan Yan, Yifei Cui, Dingzhu Liu, et al. Seismic Signal Characteristics and Interpretation of the 2020 "6.17" Danba Landslide Dam Failure Hazard Chain Process [J]. Landslides, 2021, 18(6): 2175-2192. https://doi.org/10.1007/s10346-021-01657-x.

Yan Yan, Peng Cui, Su-chin Chen, et al. Characteristics and interpretation of the seismic signal of a field-scale landslide dam failure experiment [J]. Journal of Mountain Science, 2017, 14(2): 219–236. https://doi.org/10.1007/s11629-016-4103-3.

C27: Fig. 8 caption: "Corresponding absolute values are shown as dashed black lines." How you calculate the absolute values? For what reason we need it?

R27: Thank you for the useful comment. The absolute values are the square roots of the sum of squares of three component values. We need the absolute values because, for example, an absolute sliding speed is more intuitive than a three-component velocity.

We are sorry that there is an error here. Absolute values are represented using black lines. Vertical dashed black lines marked the landslide start and end times (the first and third ones) and the time that the sliding mass reached the maximum speed (the middle one). Therefore, we made change of title of Figure 8: "Corresponding absolute values are shown as black lines."

C28: Fig. 9 caption "Red dotted lines indicate that the seismic trace was not used in the inversion." Why not used? What are your considerations?

R28: Thank you for pointing this out. We calculated the signal-to-noise ratio (SNR) of each processed seismic record and selected seismic traces with an SNR larger than 10 dB to carry out the inversion. This part was modified in the revised manuscript.

"Seismic data were processed using the following procedure before carrying out the landslide force history inversion. Firstly, they were deconvolved with the instrument response to obtain displacement; then a 4th-order Butterworth bandpass filter in the frequency band of 0.006–0.2 Hz was then applied; and finally, the records were resampled at a sampling rate of 5 Hz. The processed seismic records have a high signal-to-noise ratio (SNR) as shown in Table 3. Sixteen seismic traces with an SNR larger than 10 dB were selected to carry out the inversion.

Table 3. SNR of seismic signals used in the inversion and CC and VR of the inversion results

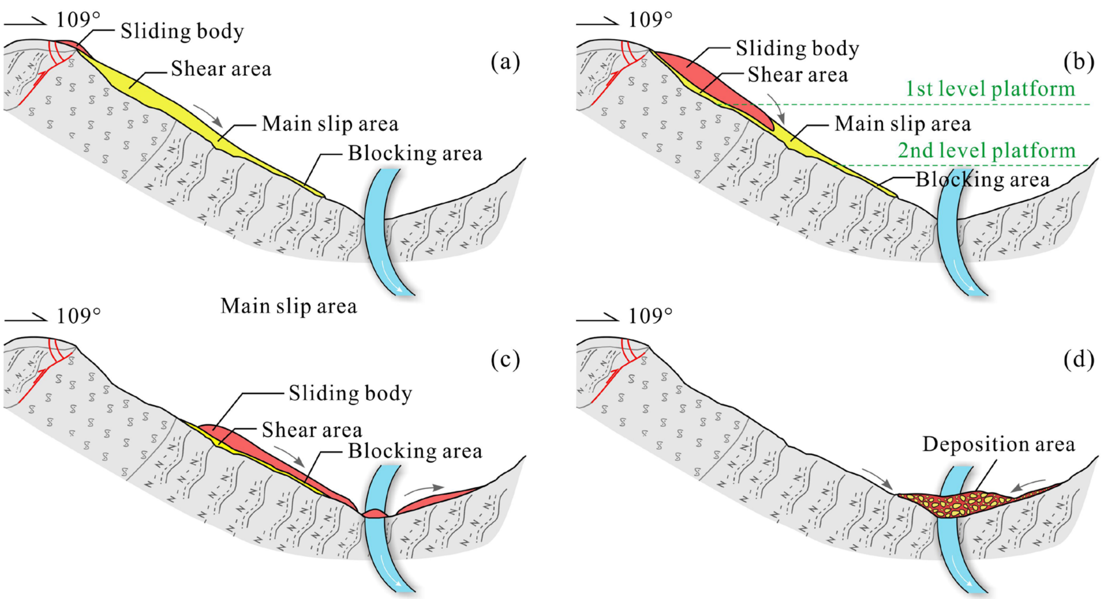
Seismic Station		Signal-to-noise ratio SNR	Cross-correlation (CC)	Variance reduction (VR)
BTA	Z	19.19	0.96	0.90
	E	4.28	0.56	0.28
	N	8.45	0.60	0.34
GZI	Z	29.63	0.99	0.99
	E	20.39	0.99	0.98
	N	15.29	0.97	0.94
LTA	Z	24.67	0.99	0.98
	E	7.92	0.86	0.71
	N	15.12	0.97	0.94
DFU	Z	23.60	0.99	0.99
	E	17.58	0.99	0.98
	N	5.92	0.54	0.28
YJI	Z	22.58	0.98	0.97
	E	11.64	0.93	0.85
	N	16.75	0.95	0.90
YUS	Z	18.05	0.94	0.89

	E	19.39	0.98	0.97
	N	18.01	0.98	0.96
BAM	Z	21.48	0.99	0.98
	E	5.86	0.74	0.53
	N	10.91	0.94	0.88

The inverted force histories are shown in Fig. 8. The good fit of the synthetic and recorded seismic waveforms in Fig. 9 and the high cross-correlation (CC) and variance reduction (VR) between synthetic and recorded seismograms provided in Table 3 indicate the high quality of the inversion results. The inverted forces show landslide initiation at 14:05:37.6, with ~61 s duration of the main motion."

C29: I wonder whether the Fig. 14 a and b shall be switched? What is the red area in Fig. 14 b? Also, please show where are the 1st and 2nd "level platforms" in Fig. 14. I don't quite get it from your description.

R29: Figure 14.a represents the initial stage, that is, a small amount of top traction area starts to slide; Figure 14.b~d red area represents the sliding body, Figure 14.b represents the landslide body in the traction area covering the shear area, resulting in The shear zone begins to slide down, and drives the main sliding zone to begin to move. 1st and 2nd level platforms are marked accordingly as shown in the figure below.



C30: Line 539~540: I think it is: "Part of the front edge of the landslide was detached on the right bank of the Jinsha River, slid up against the opposite slope on the left bank, and then …" You may reverse the right and left?

R30: Thank you for your comments. Combining other comments, we have deleted this sentence and modified the conclusions. Please refer to the reply to C32.

C31: Line 542: "that combing on-site" Wrong word.

R31: Thank you for your comments. We have deleted this word and modified the conclusions. Please refer to the reply to C32.

C32: The conclusion is not concise and complete. Many parts are redundant. I suggest you rewrite. You may want to write: a brief restatement of your research problem; summarize overall findings, and the implications of your research, etc.

R32: Thank you for the useful comment. We have now modified the conclusions as in below:

In this study, we use on-site geological survey, landslide seismic signal analysis, dynamic inversion, and numerical simulation to provides a comprehensive analysis of "10.10" Baige landslide. We used short-time Fourier transform (STFT) and PSD to analyze the seismic signals for Baige landslide. We then reconstructed the landslide force history by direct deconvolution of the observed seismograms with Green's functions. We then developed a method that use seismic inversion to constrain and calibrate the numerical input parameters using DEM. With the assessment of numerical simulation, the dynamic process of "10.10" Baige landslide was then analysed. Nevertheless, several key issues, such as friction weaking, base entrainment, particle breakage, are not considered in the DEM, which leads the difference between simulation and inversion, should be considered in future research.