Manuscript title: **“**Analysing dynamics of the 2000 Yigong landslide in the Tibetan plateau using seismic observations**”**

Manuscript ID: LASL-D-24-00845R1

Dear editor,

We are honored for the chance to resubmit our revised manuscript. We would like to express our appreciations to you, and two anonymous reviewers for their thoughtful reviews and excellent comments. We have studied these valuable comments carefully, and tried our best to revise the manuscript according to these comments.

You will find below our specific responses.

Thanks again for your consideration. We look forward to hearing from you.

Best regards,

Joanne Ho and all co-authors

Response to Editor

Please make references conform with Landslide usage and improve the quality of FIG.2 AND 6 zoom-in the text in the figure box

Thank you for your valuable feedback. We have revised the references to ensure they conform with the journal's guidelines. Additionally, I have moved previous Figure 3 to Supplementary Materials as Figure S2 to make the Results session more concise. With such updates, I have then regenerated Figures 2 and 5 (previously Fig. 6) to enhance their quality and zoomed in on the text within the figure boxes for better readability. I appreciate your suggestions and hope these improvements meet the journal's standards.

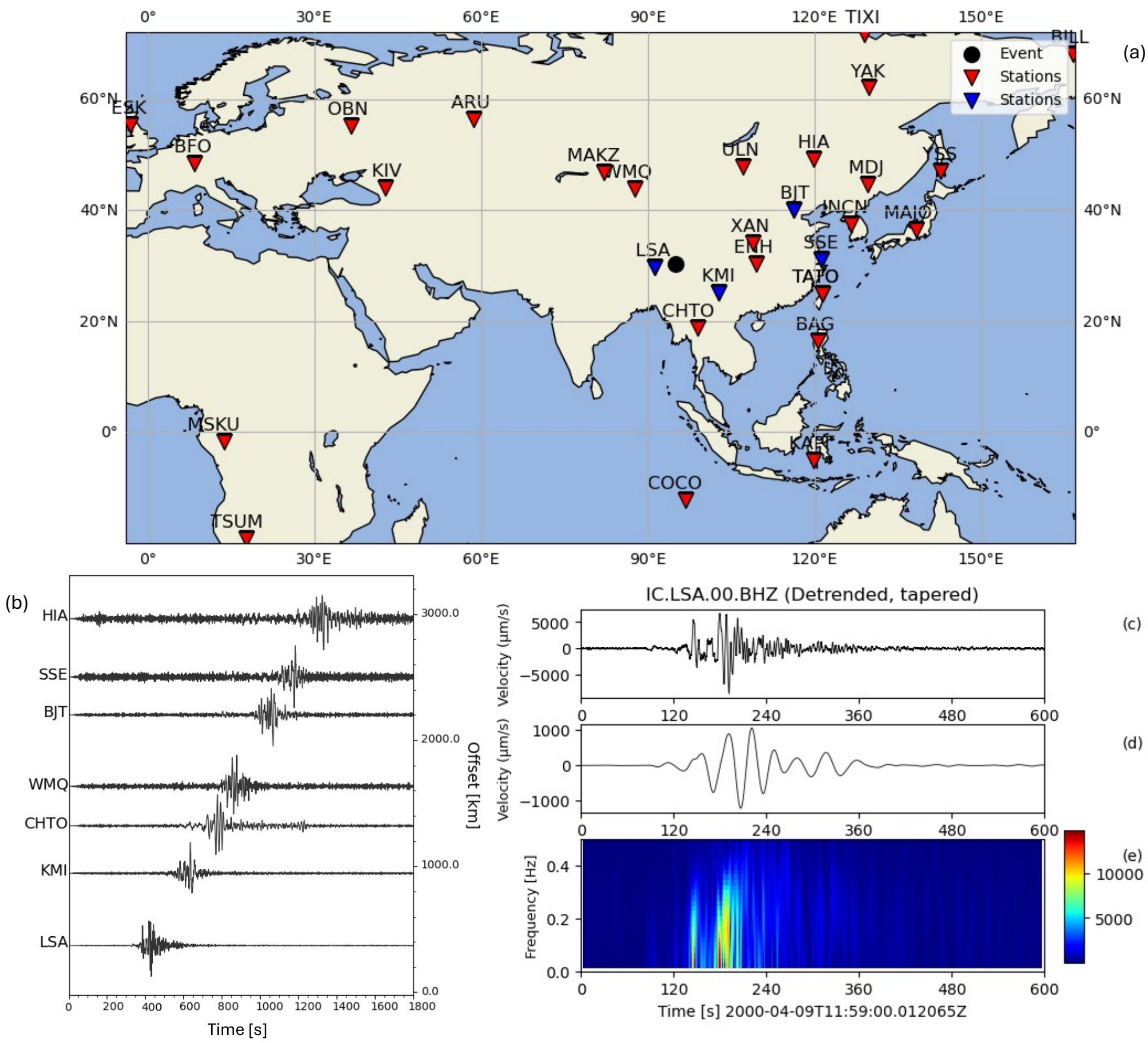

Fig. 2 a** Regional map showing the location of Yigong and selected stations (in red) with records of seismic signals generated by the 2000 landslide. Stations in blue are used in this study for seismic inversion. **b** Seismic signals of vertical component generated by the 2000 Yigong landslide recorded at stations within 3000 km from source. **c** Zoom-in vertical component seismic data of the 2000 landslide from the nearest station, IC. LSA, unfiltered seismogram, **d Same seismic waveform passed a butterworth bandpass filter at 30-150 s, ***e** Spectrogram of seismic signals with colour bar showing amplitude of signals.*

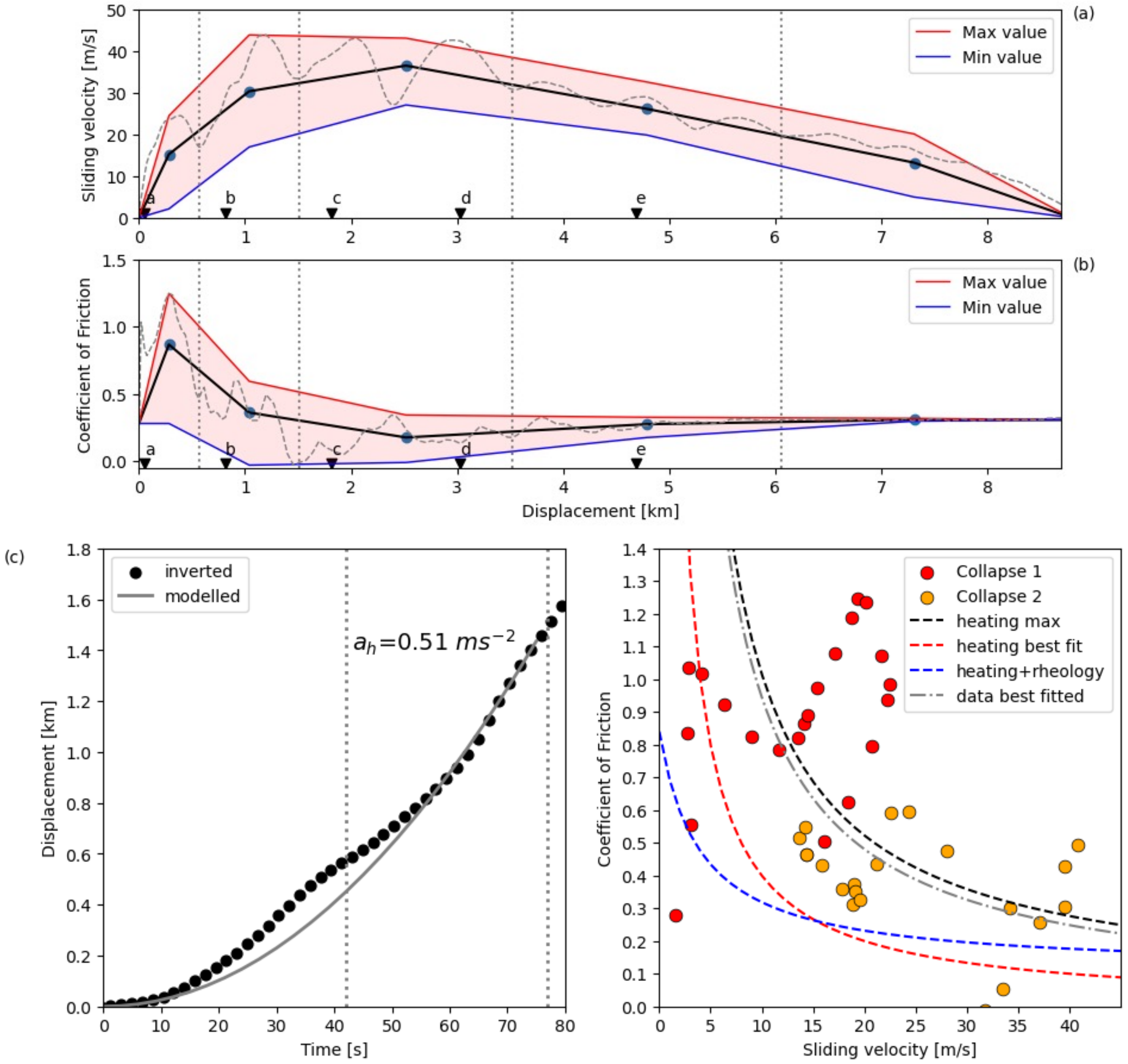

Fig. 5 *Dynamic properties inferred from seismic inversion.* ***a*** *Velocity and* ***b*** *Equivalent friction coefficient across the entire horizontal distance of the event. The maximum, minimum, and average value at each stage are shown.* ***c*** *Horizontal displacement throughout Stages 1 and 2. The data points from inversion (dots) show two-segment curve corresponding to the two acceleration stages, whereas the fitted line represents the equation of motion.* ***d*** *Correlation between velocity inferred from seismic signals and computed apparent friction coefficient for the Acceleration Phase (Stages 1 and 2) of the 2000 Yigong landslide. Scattered data show a negative exponential relationship overlay with empirical formula (Rice et al., 2006; Lucas et al., 2014).*

Response to Reviewer #1:

We would like to thank you for the specific and constructive comments you provided for this manuscript. These comments are really helpful and greatly improve this manuscript.

The authors investigate the kinematic evolution and runnning and time-dependent frictional coefficient of a rock avalanche event, specifically the 2000 Yigong landslide event, using teleseismic records acquired during the event. I suggest a major revision before reconsideration for acceptance.
The manuscript is well-written and easy to read; however, it lacks style and depth in some areas, with significant shortcomings in analysis, comparison, and validation.

Specific comments are as follows:

Abstract:
The abstract includes numerical data, which is typically not reported in this section. The reference to these data is qualitative and lacks significance as they are not contextualized within the specific procedures used.
Line 9: Replace "slumping" with "event." The term "slumping" refers to a specific landslide mechanism.
Line 11: Replace "limited observation" with "complexity of phenomena." This type of event is well-documented in the literature.
Overall, the abstract is not well-articulated and requires brevity.

Thank you for your comments. We concur with the suggestion to maintain a contextualised and qualitative approach in the abstract. In our revision, we have removed redundant lines as well as the numerical values of the dynamic parameters, such as velocity and forces, from our results, and focusing instead on describing the processes of the Yigong landslide during the various phases identified through seismic inversion. However, we retained the values for the equivalent friction coefficient, as these are key findings of our study. They highlight the significant drop in friction and suggest the potential for fluid inclusion from partial heating, which may contribute to the landslide's high mobility and long runout distance,

"We identified five distinct stages in the event's dynamics, beginning with two rock collapses in the source zone during the acceleration phase. In the entrainment phase, the mass attained its maximum velocity and forces where it impacted the Zhamu Creek. Notably, the equivalent friction coefficient dropped from 0.58 to 0.06, indicating a transition of rock collapses to debris flow. Our velocity-friction analysis aligns with flash heating theory, suggesting that high-speed sliding between rough surfaces generated heat, partially melting the glacier and introducing fluid into the sliding process, resulting in an enhanced mobility and facilitated long-runout distances down the Zhamu Creek. This study highlights the value of seismic signals in understanding

the physical mechanisms behind catastrophic landslides and addressing challenges of monitoring these geohazards in remote regions."

Introduction:
This section includes citations regarding specific issues, but does not reference similar cases. The study of waveforms to characterize runoff has been covered in the literature for many years.

Thank you for your comments and suggestion. We have now highlighted the vulnerability of landslide hazards in Tibet and included two recent, well-studied examples from the region: the 2018 Sedongpu debris flow and the 2018 Baige landslide:

"*The steep terrain and harsh conditions of the Tibetan Plateau make it one of the most landslide-prone regions on Earth, where some of the largest valley-blocking landslides known. For example, the Sedongpu debris flow and Baige landslide in 2018 blocked the Jinsha River and the Yarlung Zangbo River, respectively, the subsequent dam breach produced catastrophic outburst floods (Gao et al., 2023; Zhang et al., 2024), which projected a hazard for hundreds of kilometers downstream.*"

Please provide a better explanation in lines 63-64.

Thank you for your suggestion, we have rephrased the line to highlight the difficulties in studying friction of landslide and to emphasis on the urge of using seismic inversion to improve our understand of the topic,

"*However, the complexity in study friction and the lack of approaches to analyse high-resolution real-time data have hindered our understanding of the initiation mechanisms and evolution dynamics of landslides.*"

Seismic observations:
Line 139: "…concentrated below 0.5Hz" - This seems lower. Additionally, please reference the figure.

Thank you for your comments and suggestion. We appreciate the feedback and have revised our observation to reflect that most of the frequencies are distributed below 0.4 Hz rather than 0.5 Hz in the spectrogram. Accordingly, we rephrased that line and better referenced the figure,

"*Spectrograms showed a triangular signature in the frequency domain, with effective frequencies concentrated below 0.4 Hz (Fig. 2e), and a long duration of approximately 300 s (Ekström & Stark, 2013; Zhang et al., 2019).*"

Line 140: Figure 2d is processed using a passband filter. Specify the type of filter and verify the window size, as 30s seems too large.
Thank you for your comments and suggestion. We have clarified on the filter type in the caption of Figure 2d, "***d*** *Same seismic waveform passed a butterworth bandpass filter*

at 30-150 s,". We applied a bandpass filter window size of 30 – 150 s because our spectrogram data indicate a notable concentration below 0.1 Hz (Fig. 2e). This 30 – 150 s bandpass (otherwise 35 – 150 s and 30 – 100 s) window has been well-supported by other studies (Allstadt, 2013; Ekström & Stark, 2013; Zhang et al., 2019)

Method:
Line 182: Elaborate on the shape of the Green's function and its role in wave attenuation and dispersion with distance from the source.

Thank you for your comments and suggestion. We have incorporated feedback from Reviewer 2 to rephrase and simplify the Methodology section, as much of the methodology is based on Toney and Allstadt (2021). We retained the information regarding the shape of the Green's function as it is.

Lines 201-202: Clarify why this is true for all stations. This sentence addresses surface waves with distance.

Thank you for your comments and suggestion. To clarify, we have added Figure S1 in the Supplementary Materials. This figure illustrates the consistency of the seismic signals bandpass filtered at **a** 10 – 150 s and **b** 50 – 150 s across all selected stations. It emphasizes the wide range of seismic energy produced, highlighting the scale and complexity of the 2000 Yigong landslide. The surface waves generated by the landslide are characterised by long-period, low-frequency Rayleigh and Love waves, which usually give frequency ranges from 0.1 to 10 Hz (Aki & Richards, 1980). Additionally, the consistent recording of these long-period signals at distances, even at 3000 km from the source, indicate that this was a large-scale event.

We have addressed this question as follow,
'*The 10 – 150 s bandpass filtered seismic signal (Fig. S1a) highlights the less cohesive, localised disturbances and debris flow complexities during the entrainment and deposition phases of the landslide (Allstadt, 2013; Zhang et al., 2020). The 50 – 150 s range (Fig. S1b) captures the coherent bulk mass collapses during the acceleration phase, as these surface waves generated by the landslide are characterised by long-period, low-frequency Rayleigh and Love waves (Atkin & Richards, 1980).*'

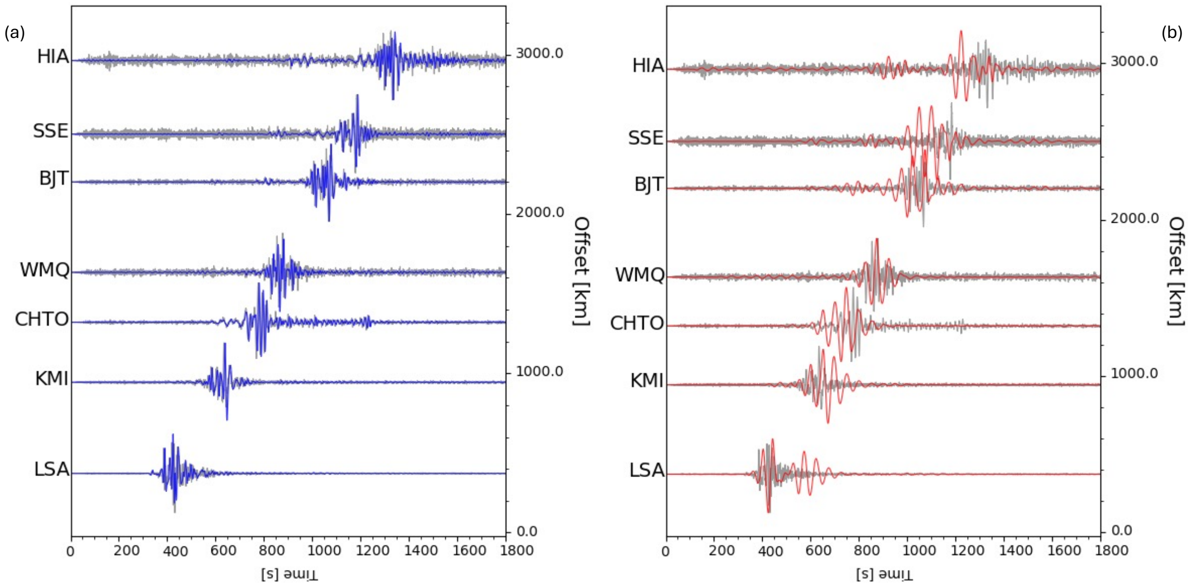

Fig. S1 *Consistent seismic signals of vertical component generated by the 2000 Yigong landslide recorded in 36+ stations across the world, this figure shows examples with signals recorded at stations within 3000 km from source.* ***a*** *Seismic signals bandpass filtered at 10 – 150 s (blue) overlapping with the original unfiltered data in grey shading.* ***b*** *Seismic signals bandpass filtered at 50 – 150 s (red) overlapping with the original unfiltered data in grey shading.*

Equation 9: The residual acceleration and sliding forces share the same sign due to gravity, so the equation should use "+" instead of "-". Consequently, the results indicate frictional angles in the travel and accumulation zones ranging from 10° to 16°. These are very low values considering the type of material (rock fragmentation with sliding and rotation) and subsoil roughness. Verify the values found in laboratory or analog tests from the literature. Additionally, a numerical simulation is necessary to validate the space-time dependent friction coefficient and velocity data. I urge the authors to recheck this formulation and subsequently reformulate the outcomes, particularly the velocities discussed.

Thank you for your suggestion. We value your feedback and have considered this comment very thoroughly. We have written Equation 1 so that the residual acceleration and the sliding force share the same sign due to gravity, as the sign acts an an indication of direction of the parameters and flow.

$$F = -F_s = -ma = -mg(\sin\theta - \mu' \cos\theta) \tag{1}$$

We then re-organised this new Equation 1 to calculate for the equivalent friction coefficient and incorporating contextual changes from other revisions, the sign for direction and mass will then be cancelled out, resulting Equation 4 will remain the same:

$$\mu'(t) = (\sin\theta - \frac{a(t)}{g})\cos^{-1}\theta \qquad (4)$$

In general, the friction coefficient derived using this method encompasses various effects, such as fluidization, fragmentation, fluid pressure, and surface smoothing during sliding and rotation. Therefore, it would be more appropriate to refer to the friction coefficient as an "equivalent coefficient" representing the opposing force.
Thank you for your comment and suggestion. We appreciate your input and have incorporated the term as recommended.

Discussion:
This section should include comparisons and validations to support the method's performance and accurately define the frictional coefficient as the target of the method used.
Thank you for your comment and suggestion. We have included a comparison with the friction study of the same landslide conducted through numerical modeling by Guo et al. (2024). Their results closely align with ours, reinforcing our findings:

"Furthermore, our results are consistent with those of a recent study by Guo et al. (2024), corroborating the authors' findings regarding the entrainment area from numerical simulations, which their results give a maximum velocity of 43.6 ms-1 with friction coefficient dropping from 0.64 to 0.1 and highlighted the potential of friction weakening effects. Nonetheless, our findings and methodology emphasize the importance of higher-resolution time-velocity constraints, significantly enhancing near-real-time solutions for geohazard management."

References

Allstadt, K. (2013) Extracting source characteristics and dynamics of the August 2010 Mount Meager landslide from broadband seismograms, *J. Geophy., Res. Earth Surf.*, 118, 1472-1490, https://doi.org/10.1002/jgrf.20110

Aki, K., & Richards, P. G. (1980). Quantitative Seismology: Theory and Methods. San Francisco, CA: W.H. Freeman

Ekström, G., Stark, C. P. (2013) Simple scaling of catastrophic landslide dynamics, *Science*, 339 (6126): 1416-9. https://doi.org/10.1126/science.1232887

Gao, Y., Li, B., Gao, H., Gao, S., Wang, M., Liu, X. (2023) Risk assessment of the Sedongpu high-altitude and ultra-long-runout landslide in the lower Yarlung Zangbo River, China. *Bull Eng Geol Environ* **82**, 360 . https://doi.org/10.1007/s10064-023-03374-2

Guo, Z., Zhou, X.,Huang,D., Zhai, S., Tian, B., Li,G. (2024) Dynamic simulation insights into friction weakening effect on rapid long-runout landslides: A case study of the Yigong landslide in the Tibetan Plateau, China, China Geology, 7 (2), 222-236, ISSN 2096-5192, https://doi.org/10.31035/cg2023132.

Toney, L., Allstadt, K. E. (2021): lsforce: A Python-Based Single-Force Seismic Inversion Framework for Massive Landslides. *Seismological Research Letters*, 92 (4): 2610–2626. https://doi.org/10.1785/0220210004

Zhang, Z., He, S., Liu, W., Liang, H., Yan, S., Deng, Y., Bai, X., Chen, Z. (2019), Source characteristics and dynamics of the October 2018 Baige landslide revealed by broadband seismograms, *Landslides*, 16, 777-785, https://doi.org/10.1007/s10346-019-01145-3

Zhang, Z., Tan, Y. J., Walter, F., He, S., Chmiel, M., & Su, J. (2024). Seismic monitoring and geomorphic impacts of the catastrophic 2018 Baige landslide hazard cascades in the Tibetan plateau. *Journal of Geophysical Research: Earth Surface*, 129, e2023JF007363. **https://doi.org/10.1029/2023JF007363**

Response to Reviewer #2

We would like to thank you for the specific and constructive comments you provided for this manuscript. These comments are really helpful and greatly improve this manuscript. Below are our specific responses to your comments and suggestions.

The article "Analysing dynamics of the 2000 Yigong landslide in the Tibetan plateau using seismic observations" describes the potential, spatio-temporal evolution of a huge landslide occurred on 9th April 2000 in China. To do so, the authors employed a recently-developed software devoted to the reconstruction of time series of forces from seismic signals. The results allowed the authors to identify five main stages of the event and to infer several aspects concerning the physical processes potentially occurred within the flowing mass.

In my opinion, considering the topic and the content, the article certainly fits with the aim of a technical note on "Landslides". However, as a technical note concerning a well-known case study, it is fundamental not only to clarify the obtained results, but also to compare them with the results reported in previous studies that the authors cited in the text. In this respect, the "Comparison with previous studies" subsection is very concise, while it should be the core of your discussion. Different parts of the manuscript are quite speculative, and then the readers should clearly understand if your inferences are coherent (or not) with preceding works.

In a broader view, I think the "Results" and Discussions" sections should be deeply modified in this manner:

* "Results" section: "The Dynamics of the 2000 Yigong Landslide" and "The Five Stages of the 2000 Yigong Landslide" are very long and a bit chaotic. You should merge them in a unique sub-section, clearly distinguishing between the description of the process evolution and the analysis of the dynamic parameters.

Thanks for your feedback. We apologise for the unclear phrasing and are committed to improving in this area. We have taken your suggestion into account and have renamed and restructured the “Results” section, eliminating redundant descriptions of the potential processes involved in the landslide. Specifically, we now focus on the results and analyses of the dynamic parameters of the 2000 Yigong Landslide in the relevant section, along with our interpretations.

* "Discussions" section: beyond the improvement of the "Comparison with previous studies" sub-section, the authors should move the "Investigating the frictional weakening" into the "limitations" sub-section, since this part is highly speculative and, in my opinion, should be included in the drawback of your analyses.
Thus, I suggest the authors to put efforts in fixing the above-mentioned issues. In doing so, I also suggest to cite the figures in progressive order, enhancing the readability of

the entire manuscript. Please also check the English language (I found several typos and different sentences with an ambiguous structure).

Thank you for your comment; we greatly appreciate your feedback. We acknowledge that our work is somewhat qualitative in nature, as it is based on observational studies. This research represents a pioneering effort to utilise high temporal resolution seismic data to analyse the time-series of frictional properties in landslides, involving several assumptions due to the limited availability of robust case studies for comparison. Furthermore, while this study identifies various factors that influence friction, additional auxiliary data and further case studies are needed to deepen our understanding of the mechanisms controlling landslide friction. Looking ahead, we are eager to consider a broader range of aspects and methodologies in studying the friction of landslides, especially as more diverse data becomes accessible in the future:

*"**Limitations***

That said, due to This study employs high temporal resolution seismic data to analyse dynamic properties in landslide. But the lack of data availability and insufficient robust case studies for comparison necessitates several assumptions, thus we can only assess the possibility of flash heating and friction-velocity weakening theory to explain the sharp frictional reduction phenomenon observed in Figure 6 5b. Apart from flash heating, numerous other factors influence friction, While it identifies factors influencing friction, additional data and case investigations are needed to better understand the other elements controlling landslide processes, including but not limited to temperature, fluid pressure, cohesion of particles, fragmentation spreading, and grain size (Vardoulakis, 2002). To assess other mechanisms, we need additional data to support the investigation; for instance, terrain data for thickness to examine the rheology of flow (Lucas et al., 2014).

In addition, there are limitations in using seismic data and inversion to infer dynamic properties due to simplification of our methodology, such as the assumption of a simple block model and the inability to fully represent the transition to an incoherent debris flow (Allstadt, 2013; Ekström & Stark, 2013; Lucas et al., 2014). These should be considered in future analyses, particularly resolving for the growing volume of sliding mass throughout the landslide. For simplicity, we assumed a constant average mass in the model as a constrain for the dynamics. Although this assumption leads to an overestimation of mass in Stages 1 and 2, the accelerations will be larger in the two stages with potentially smaller mass, which will further strengthen our result that the collapsing bulk mass accelerated during these two stages. Moreover, this seismic method only accounted for a coherent bulk mass, hence motion inferred beyond the acceleration stage does not closely align with an incoherent debris flow that will elongate and alter its shape as it flowed down the Zhamu Creek. More complexity is also expected during entrainment and transition. Employing high-frequency seismic analysis and Empirical Green's Function inversion (Zhang et al., 2020; Zhang et al., 2021) may provide more insights into the complex flow dynamics during these phases.

Besides, due to the limitations of our current observations and the constraints in our methodology, there might be uncertainties in explaining the initiation mechanisms. We proposed that rocks and glaciers gradually collapsed in a series of disintegrations, triggering further instability first in the east and then the north of the cliff during Stages 1 and 2, leading to a volume build-up (Xin et al., 2021; Fig. 4a). This interpretation is supported by fluctuations (sub-peaks) in the east and vertical components of the force-time function during the 10–150 s analysis (Figs. 3b and 3d), likely indicating smaller-scale collapses (Allstadt, 2013). The increasing force magnitudes across all components during Stages 1 and 2 (Figs. 3b, 3c, and 3d) suggest acceleration of the collapsing mass. Alternatively, the rising seismic amplitudes (Fig. 3a) may indicate a growing volume released in two stages. Our preferred interpretation aligns with previous studies (Xu et al., 2012; Xin et al., 2021) and suggests a two-collapse mechanism, with the main collapse directed westward, leaving a V-shaped scar at the source (Fig. 1d)."

Here you can find a list of further, minimal issues which should be fixed:
* Line 34: "Huggel et al 2012": this work is not included in the reference list. Check all cited references throughout the manuscript.
* Line 45-46: references should be cited in chronological order. Check this issue throughout the manuscript.

Thank you for your comment and reminder. We appreciate your input and have carefully reviewed all the citations and references and amended accordingly.

* Line 97: in my opinion, figure S1 shows an interesting detail of the source area, and then deserves to be included in the main text as part of Figure 1.

Thank you for your feedback. We appreciate your input and have incorporated the previously supplementary figure into the main text.

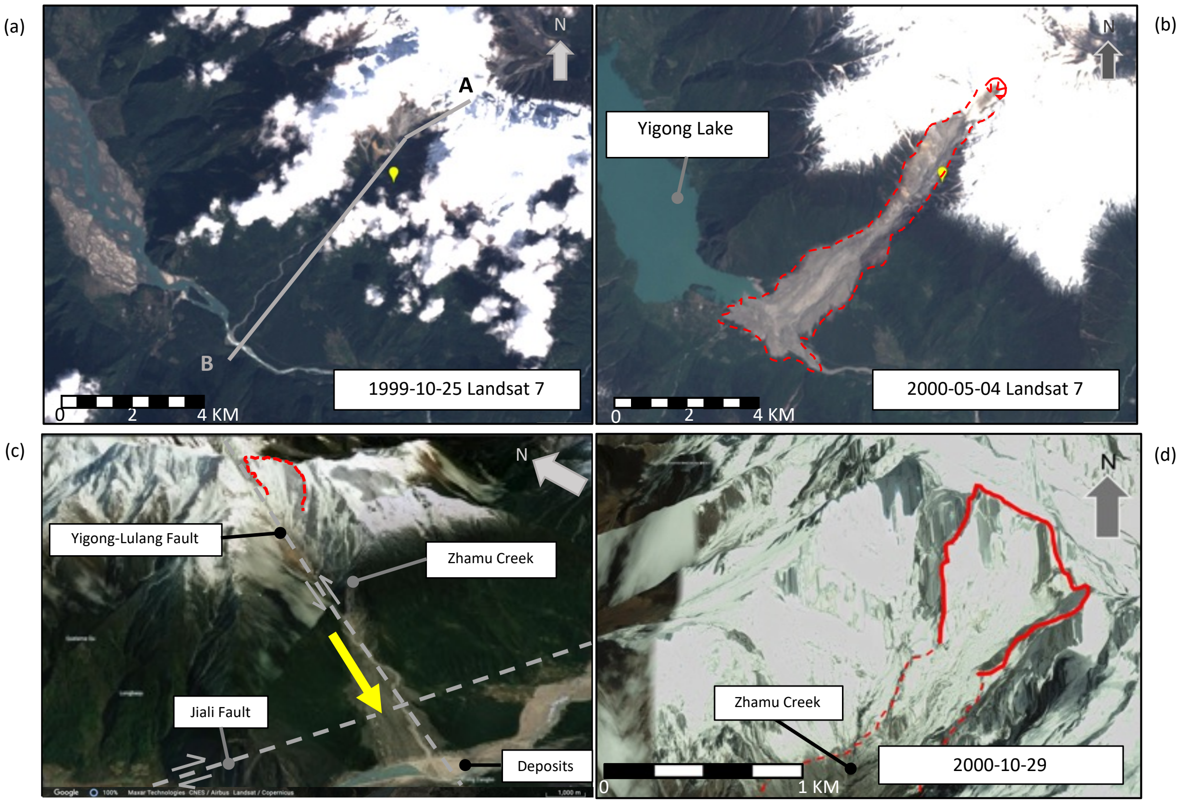

Fig. 1 *Geographical and geological overview of Yigong.* ***a*** *Satellite image from before the 2000 Yigong landslide.* ***b*** *Satellite image less than a month after the 2000 event showing the scar (outlined in dashed red line) with sediments deposited down the creek and dammed the Yigong-Tsangpo River.* ***c*** *Major structural features in Yigong. Source area of the 2000 landslide in red, regional faults in grey, and direction of slump marked by yellow arrow (After Dai et al., 2021; extracted from Google Earth).* ***d*** *A close-up view of the crown of the 2000 Yigong landslide captured by a satellite image sourced from Landsat/Copernicus on 29th Oct 2000. The solid red line outlines the V-shaped scar in the source region, which features an angular cliff face at the top of Zhamu Creek (5,260 m a.s.l.). This corresponds to the two mass collapses observed in the field (Xu et al., 2012; Xin et al., 2021), with seismic interpretations in this study indicating movement first from the east of the cliff and then from the north. The dashed red lines indicate the path along which the mass slid down Zhamu Creek, showing lineations created by the dragging of snow and soil. The satellite image was last accessed via Google Earth Pro on August 29, 2024.*

* Line 98-99: "The collapsed mass was estimated at 4 × 3.5 × 0.11 km (L×W×D), totalling 3 × 10^8 m^3 (Ekström & Stark, 2013)." Honestly, I could not find this specific information in the article you cited. Furthermore, the extension does not seem to be coherent with the volume. Could you clarify how you obtained these values?

Thank you for your comment, please accept our apologies for any misleading statements and poor referencing. I would like to clarify that the dimensions were not obtained from Ekström and Stark (2013); they were measured using satellite imagery in ArcGIS. Only the estimated volume was cited from the referenced literature:

“The collapsed mass was estimated at 1.8 × 1.2 × 1.26 km (max. L×W×D) based on measurements from satellite images and elevation data using GIS tool, totalling 3 × 10^8 m^3 (Shang et al., 2003; Ekström & Stark, 2013).”

* Line 107: "2,296 m a.s.l.". I think that the deposition area has a certain (even if minimal) altimetric variability. Is it an average value of the entire deposition zone? Please clarify it.

Thank you for your comment. We appreciate your input and have carefully rephrased the elevation in the deposition zone, based on topographic measurements from GMRT DEM data:

“The collapsed source sits at 5,260 m a.s.l., and the slumped mass was deposited between 2143 m and 2376 m a.s.l., with the mean at 2,296 m based on GMRT DEM topographic data. The runout distance of the mass centre was 8.79 km, resulting in a Heim's ratio of 0.230 for the 2000 Yigong landslide.”

* "Seismic observations" sub-section: you presented the seismic data reported in Ekström & Stark, 2013, but it is not clear why. Did you use such data in your analyses? Did you compare such data with yours? Please clarify this issue. Every section of a manuscript must have a reason for being there.

Thank you for your comment and suggestions, we apologise for the poor phrasing. To clarify, we retrieved our data from the public domain via IRIS, the Incorporated Research Institutions for Seismology, Synthetics Engine web service (Syngine, Krischer et al., 2017) using the IASP91 Earth velocity model (Kennett, 1991), using Python for manual coding and processing with the lsforce package. Whereas Ekström and Stark (2013) published their results on the detection and location of seismic events that emit teleseismically detectable long-period seismic waves is accomplished using the algorithm described by Ekström (2006). The initial analysis makes use of seismograms collected from global networks in near-real time, and automatic results are posted on the Global CMT web site (2012).

* Line 141: "fig. 2b". Why don't you cite fig 2a in the text? Each figure within the manuscript should be cited in the text, considering the progressive order. Otherwise, one might think that a figure is not particularly useful. Please check this issue throughout the text.

Thank you for your comment and reminder. We appreciate your input and have carefully reviewed all the citations and references and amended accordingly.

* "Method" section: probably this section could be strongly shortened, considering that your work concerns the application of the software "*Isforce*", which is fully described in Toney and Allstadt (2021).

Thank you for your feedback. We appreciate your input and have revised the methodology section to enhance its clarity by reducing the number of equations. Specifically, we have: 1) combined the previous Equations 1 and 2, 2) removed the former Equations 4–6, as their details are described in Toney and Allstadt (2021), and 3) combined the previous Equations 7 and 8, to give only four equations in this revision:

In the ***Method*** section:

"We adopted the methodology outlined by Allstadt (2013) and processed the inversion using the Python-based package, lsforce, developed by Toney and Allstadt (2021). For a simplified model of a sliding block mass on an incline, the net force (F) is an equal reactive force experienced by the sliding mass at the slope surface in an opposing direction of the sliding force (F_s), which arises from the difference between the gravitational force, the counteracting friction, and the centripetal forces in Equation 1. F can also be described as a single-force mechanism within the long-wavelength limit (Kanamori & Given, 1982; Takei & Kumazawa, 1994; Fukao, 1995; Allstadt, 2013; Ekström & Stark, 2013; Li et al., 2019). Topographic variations and lateral displacements during the slide are trivial as they have little influence on the long-period seismic signals when compared to the distances from the landslide source to the seismic stations (Allstadt, 2013; Toney & Allstadt, 2021).

$$F = -F_s = -ma = -mg(\sin\theta - \mu' \cos\theta) \qquad (1)$$

where m is a constant mass of sliding block, a corresponds to the acceleration of mass, gravitational acceleration $g = 9.81$ ms^{-2}, θ is the slope angle, and μ' represents the apparent dynamic coefficient of friction that accounts for basal pore fluid pressure."

In the ***Inversion Setup*** section:

(conti.) *"We model the observed waveforms as synthetic seismic records, which capture the effects of source $F(t)$ and wave propagation $g(t)$ through the Earth at each station as the three-dimensional displacements over time. The Green's Functions mathematically describe the response of the three-dimensional displacements induced by a unit impulse force in vertical (V) and horizontal (H) directions. The resultant 3-dimensional force-time series is expressed in north (N), east (E), and vertical (Z) directions, $F(t) = [f_N(t), f_E(t), f_Z(t)]$, which corresponds to the ground displacements in the vertical (Z), radial (R), and transverse (T) components accounting for the azimuth ($\emptyset$) from source to station clockwise from north that accounts for the radiation pattern of seismic waves. A positive vertical force component indicates downward motion of mass, while the north and east forces describe the direction of slide (Allstadt, 2013)."*

In the ***Trajectory*** section:

"Using the best-fitted three-component force-time functions from seismic inversion with the assumptions stated, we calculate the centripetal acceleration of the landslide by rearranging Equation 1, then integrate the time-varying acceleration once to yield the

velocity and twice to compute displacement of the slide,

$$u(t) = \int v(t)\,dt = \iint a(t)\,dt = \frac{1}{m}\iint F(t)\,dt \qquad (3)$$

For more in-depth kinematic analyses, we resolve for the landslide's runout path and direction. With georeferenced satellite imagery but lack of instantaneous topographic data from the Digital Elevation Model (DEM) in the Yigong area, we validate the landslide trajectory using a Landsat 7 satellite image captured on 4th May 2000, which gives a measured runout distance of the landslide centre of mass as 8.79 km. Additionally, we define the event duration as 485 seconds, which is observed from the inverted force-time functions (Fig. 4) and seismic records (Fig. 2c)."

* "Results"-inversion validation: this sub-section is very concise and does not add much to the article. I suggest moving to the "Supplementary material". Otherwise, add more details about the validation process.

Thank you for your suggestion, we have rephrased the inversion validation with details and removed the inversion results figure to Supplementary Materials.

*"**Inversion Validation***
The inversion analysis achieved a 72% variance reduction, indicating a promising consistency between the observed and synthetic data (Fig. S2), suggesting reliable results from the inversion (Toney & Allstadt, 2021). Furthermore, the force-time series exhibited a consistent pattern across the 10 – 150 s and 50 – 150 s filter bands (Figs. 3b, 3c, and 3d), reinforcing the robustness of the interpretation. Additionally, variations at both higher and lower frequencies reflect the intricate dynamics of the landslide (Kanamori & Given, 1982; Fukao, 1995; Ekström & Stark, 2013; Hibert et al., 2014). We also validate the trajectory of the centre of mass by overlaying the time-lapse horizontal displacements with satellite imagery (Fig. 4a). The computed trajectory closely aligns with the crown at source, the scar and topographic depression along Zhamu creek, and the deposits at the Yigong River. The time-lapse analysis tracks the position of the sliding mass throughout the event with time stamps (Fig. 4a), where we identified 5 points, a to e, that correspond to local maxima in the force history and the potential impact points (Fig. 4a). Based on the force history profile and the inferred dynamic parameters (Figs. 3b, 3c, 3d, and 4a), we identified five distinct stages of the landslide."

And in the ***Supplementary Materials***,

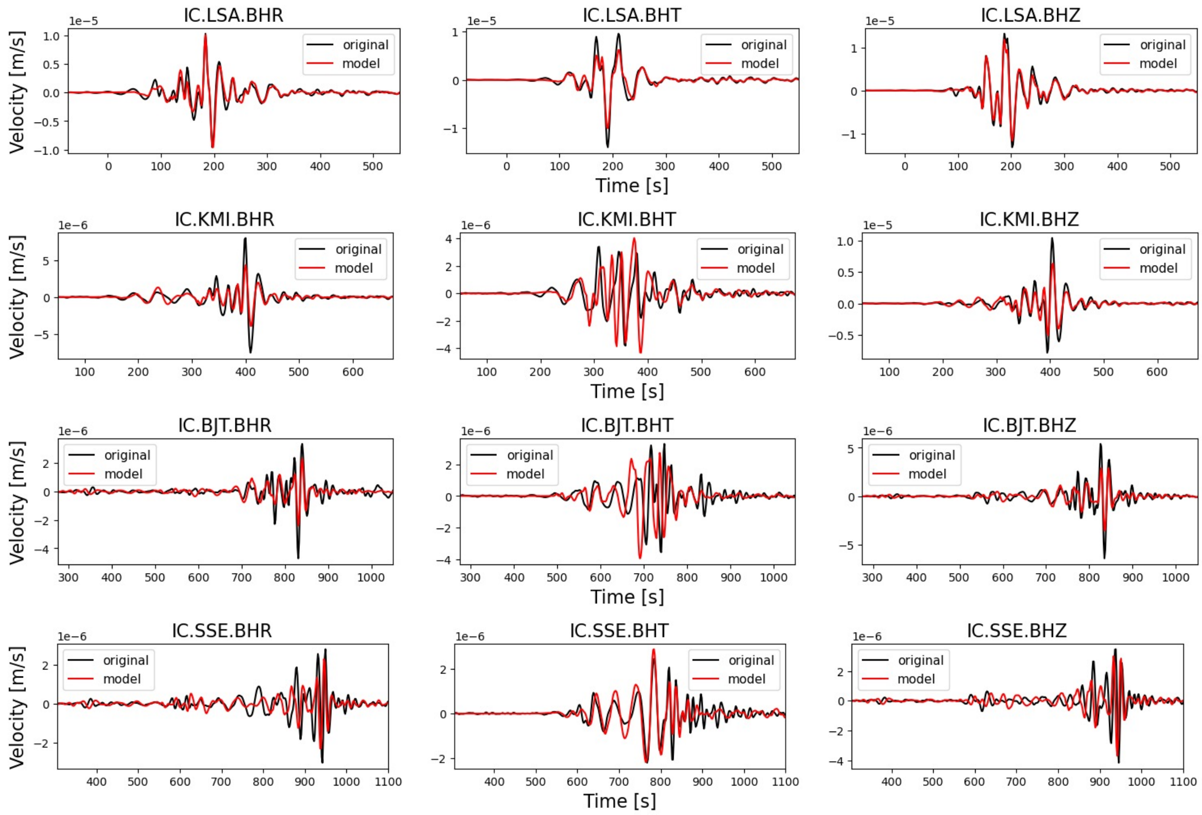

***Fig. S2** Comparison between modelled (red) and observed (black) seismic waveform at the four selected stations, applying a bandpass filter of 10 – 150 s. A variance reduction of 72% was obtained.*

References

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