Response to reviewers (essd-2024-382)

Earth System Science Data

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Title: A worldwide event-based debris-flow barrier dam dataset from 1800 to 2023

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Dear Editors and Reviewers,

We sincerely thank the Editor-in-Chief Dr. Hanqin Tian, the Handling topic Editor Dr. Yuanzhi Yao, the Reviewer Dr. Tran, Thanh-Nhan-Duc, and the two anonymous Reviewers for their precious time and insightful comments. Your suggestions and feedbacks are very helpful for us to improve the quality and readability of our manuscript.

In response, we have carefully revised the manuscript and the provided point-by-point responses to each of your comments. The **comments** are presented in **bold font**, followed by our **responses** in **standard font**. Any **changes/additions** to the manuscript are highlighted in *red text*. For example, the notation ***P2L16~32*** refers to **line 16~32** on **page 2** of **the revised manuscript**. Additionally, following the reviewers' suggestions, we have added a "2.4 Data analysis tools" section in the revised manuscript. This section is dedicated to introducing the tools used for data collection, validation, and analysis. We have also uploaded files in KMZ format, which are the intermediate files that we used to obtain and validate the channel length, channel slope gradient, and gully basin area of debris flows.

We hope that the revisions meet the requirements for publication in *Earth System Science Data*.

Best regards,

Kaiheng Hu on behalf of all co-authors

The Response to Comments from Review 1 (Dr. Tran, Thanh-Nhan-Duc)

Comment 1 **First and foremost, the proposed idea of constructing a dataset of debris-flow barrier dams (DFBDs) is unique and novel, and I believe it is significantly important to publish. Additionally, I acknowledge the substantial amount of work the authors have done to construct this dataset, which involved carefully reviewing over 2,500 high-quality literature sources and media reports. Regrettably, I must decline the work in its current form, but I would be happy to review it again after substantial revisions have been added. Specifically, there are several major concerns with this dataset that are unacceptable and must be addressed.**
Response 1 We would like to express our heartfelt gratitude for your appreciation of our research work, particularly your generous praise for the construction of the debris-flow barrier dams (DFBDs) dataset. We are truly honored that you think this dataset to be unique and novel. We acknowledge that, despite our extensive efforts in reviewing and organizing 2,519 high-quality pieces of literature and media reports, the creation of this dataset is a complex and ongoing process that requires continuous enhancement and refinement. We agree with your comments that the dataset, in its current form, has certain issues that need to be addressed. We are committed to improving this work in response to your valuable comments and suggestions.
Comment 2 **While the dataset is proposed as a worldwide collection, covering data back to the 1800s, which is impressive, only 555 dams were included. This number seems unreasonably low for a 'worldwide' scale. I am generally doubtful of this outcome.**

Response 2

Thank you for your comments! The debris-flow barrier dams (DFBDs) included in our dataset were meticulously compiled from documented literature and news reports. We acknowledge that our dataset does not encompass all DFBD events. In response to your doubt, the reasons for the small number of DFBDs in the dataset have added in section 4.4, “Limitations in this work.” ***(P36L765~781)***

“In addition, we acknowledge that our dataset does not encompass all DFBD events. The number, 555 dams, seems unreasonably low for a 'worldwide' scale, which may be attributed to the following reasons: (1) in the process of data collection, it is inevitable that some literature or reports might be missing, and some unreported events are not included; (2) it is obvious that only large-scale debris flows have the potential of damming rivers. However, the number of debris flow events is smaller than that of other type of landslides with the same magnitude; (3) current research on barrier dams focuses more on LDs, with less attention given to DFBDs (see Table 1), hence the limited availability of literature we could consult; (4) due to their poor stability (Fig. 6(a)) and short-lived existence(Fig. 6(d)), many DFBDs quickly disappeared, and it is difficult to detect and record them timely; and (5) for the records of early debris-flow disasters, people paid more attention to the influences on human lives and infrastructure, while lacking sufficient understanding and attention to the blockage of river channels by debris-flows. As a result, such events were often overlooked in historical records, leading to a seemingly smaller number when viewed from the perspective of historical data statistics.”

In comparison to other barrier dam datasets, our collection includes only 555 DFBDs, which may not seem substantial. However, our dataset is distinctly focused, being the first global compilation specifically of DFBDs. We prioritize the thorough review and validation of raw data rather than providing a simple summary of existing literatures and reports.

It is important to emphasize that while our dataset may have limitations in terms of quantity, it represents the first comprehensive global dataset of DFBDs. Given the scarcity of such data, this dataset has the potential to significantly enhance our understanding of the formation and evolution of DFBDs.

Comment 3

The data review and validation process was conducted using Google Earth. While this is a traditional and effective approach that I believe many other researchers use when building datasets on dams and reservoirs, it raises the question of how far back the authors were able to retrieve data, especially to validate the geographical coordinates and dates of formation going as far back as 1800. This is a difficult question that I believe the authors need to revisit and carefully consider. Furthermore, the manuscript points out discrepancies between the reported formation dates from data sources (literature) and Google Earth. This raises the question: which source is correct, and how can this be confirmed?

Response 3

Thanks for your valuable comment.

1. We obtained the formation date of debris-flow barrier dams (DFBDs) by referring to literature or news reports. We utilized Google Earth to verify the formation date whenever corresponding imagery is available. If the formation date provided in the literature or news reports does not align with the information obtained from Google Earth, we believed it is not feasible to accurately establish the exact formation date, and as such, we refrained from recording it. For DFBD events with a longer history, if Google Earth does not provide relevant imagery, we relied on the available literature or news reports to determine the formation date; if the formation date is not recorded in the literature or news reports, the formation date information was not included in

our dataset. In response to your comment, we have provided additional explanations regarding the acquisition and verification of formation date information in Section 2.3 “Data processing procedure” of the revised manuscript. ***(P15~16L279~295)***

“- ***Date of formation.*** We obtained the formation dates of DFBDs by referring to literature or news reports, and primarily used Google Earth for verification.

(1) The formation dates were recorded in the literature or news reports.

1) When corresponding Google Earth imagery was available, we used Google Earth to verify the formation dates. If the formation dates provided in the literature or news reports were consistent with the information obtained from Google Earth, we considered this information reliable and included the formation dates in our dataset; if there was a discrepancy between the formation dates provided in the data sources and the information from Google Earth, we believed it was not feasible to accurately determine the formation dates and, therefore, did not record them.

2) However, for some events that date back a long time (for example, DFBDs formed between 1800 and 1900), Google Earth did not provide relevant imagery. In such cases, we relied on the available literature or news reports to determine the formation dates.

(2) If the date of formation was not recorded in the literature or news reports, our dataset would not include the formation date information.”

2. Regarding the geographical location of the DFBDs, when the data source included latitude and longitude information and corresponding imagery was available on Google Earth, we verified these coordinates through the platform. If discrepancies arise between the latitude and longitude provided by the data source and the results from Google Earth, we prioritize the Google Earth data. This is because Google Earth offers continuously updated satellite imagery and geographic data, while manually recorded literature and

news reports may contain inaccuracies or biases. The automated data collection and processing capabilities of Google Earth help mitigate the risk of such human errors. For historically remote DFBD events, if we cannot locate imagery on Google Earth, we depended on the geographical coordinates reported in the data source. When latitude and longitude information were not provided by data sources, we utilized landmarks described in the sources to determine their coordinates using Google Earth. We have detailed the process of acquiring and verifying latitude and longitude information in Section 2.3 "Data processing procedure" of the revised manuscript. ***(P15L257~278)***

"-Longitude and Latitude. When determining and verifying the longitude and latitude information, we took the following measures.

(1) The data sources provided latitude and longitude information.

1) When the data sources included latitude and longitude information and corresponding imagery was available on Google Earth, we verified these coordinates through the platform. If discrepancies arise between the latitude and longitude provided by the data source and the results from Google Earth, we prioritize the Google Earth data. This is because Google Earth offers continuously updated satellite imagery and geographic data, while manually recorded literature and news reports may contain inaccuracies or biases. The automated data collection and processing capabilities of Google Earth help mitigate the risk of such human errors.

2) For the events with a long history, we cannot locate imagery on Google Earth, we depended on the geographical coordinates reported in the data source.

(2) The data sources did not provide latitude and longitude information.

1) If the corresponding remote sensing imagery was available, we located the landmarks described in the data sources on Google Earth, compared the imagery before and after the formation date of the DFBD, and thereby

determined the geographical coordinates of the DFBD on Google Earth.

2) If there is no corresponding remote sensing image, we did not record geographic coordinate information."

Comment 4

The dataset is described as worldwide, but the majority of the dams are located in China. While this may be reasonable, given the authors' location, it creates a significant bias when only 39 dams are recorded in Italy, 43 in Japan, 33 in the United States, and 64 in other locations, compared to 333 in China. The authors should carefully reconsider whether they intend to maintain a global scale or refocus the dataset only within China mainland.

Response 4

We would like to express our sincere gratitude for your meticulous review and valuable comments on our research. We have provided a detailed explanation for why DFBDs in China are significantly more numerous in Section 3.2 "Spatiotemporal distribution of the DFBDs" of the revised manuscript. ***(P20~21L407~435)***

"The number of Chinese DFBDs in the dataset is significantly high, which can be mainly attributed to the following reasons. (1) Active geological activity: China is located at the junction of multiple tectonic plates, with complex geological structures and active neotectonic movements, leading to frequent earthquakes. Earthquakes cause rock fragmentation and mountain loosening, producing a large amount of loose soil and stone, providing a rich source of material for the formation of debris flows. For example, after the 2008 Wenchuan earthquake, a large number of debris flow dam events occurred in the earthquake-affected area and its surroundings (Fan et al., 2012a; b; 2017; 2019; Shi et al., 2015). (2) Diverse climatic conditions: China has a rich variety of climate types, with a significant monsoon climate and concentrated rainfall, often in the form of heavy storms. In some mountainous areas, intense rainfall over a short period can rapidly increase surface runoff, carrying a large amount of silt, rocks, and other materials to form debris flows. Additionally, in high-altitude glacial regions, the melting of glaciers and snow due to rising temperatures in summer can also provide ample water sources for debris flows, promoting the formation of debris flow and DFBDs. (3) Complex topography and geomorphology: China has a vast mountainous area with significant terrain undulations, crisscrossing valleys, and notable elevation differences. Especially in the western and southwestern regions, such as the edges of the Tibetan Plateau (Jiang et al., 2022; Zhou et al., 2024) and the Hengduan Mountains (Zhou et al., 2022), the high mountains and deep valleys with steep slopes and rapid streams provide favorable topographical conditions for the formation of DFBDs (Fig.6(a)). A large amount of loose solid material is prone to accumulate in valleys, and once triggered by an appropriate water source, it is easy to form debris flows that can dam rivers and create DFBDs. Although other countries like Japan frequently experience debris flows, there are few topographical conditions, such as deep valleys and high relief, that are conducive to the formation of debris flow dams; therefore, there are fewer DFBDs in Japan."

We acknowledge the geographical bias you mentioned, which is indeed a valid concern. In response to your concerns regarding geographical bias, we have addressed the limitations of the spatial distribution of DFBDs in Section 4.4 "Limitations in this work" of the revised manuscript. ***(P36~37L782~800)***

"In this dataset, the number of DFBDs in China is significantly higher than that in other countries and regions, which may be attributed to the fact that China's active geological activity, diverse climatic conditions, and complex topography and geomorphology conditions are more conducive to the formation of DFBDs (see Section 3.2 for details). However, we cannot rule out the possibility that the spatial distribution of DFBDs in this dataset may be biased. In our efforts to create a global DFBD dataset, we encountered challenges that are common in the data collection process, which may contribute to such biases. For instance, the recording and reporting of DFBD events can vary by region, influenced by local research focuses, data recording practices, and the availability of scientific resources. Furthermore, access to DFBD event data in some countries may be restricted due to data privacy policies, language barriers, or a lack of digitization. The diversity of languages in global literature and reports adds complexity to data collection, particularly when extracting information from non-English sources. Additionally, different countries and regions may employ varying standards and definitions for DFBD events, complicating data comparison and integration. Our team's geographical and resource acquisition advantages facilitate the collection of a greater number of Chinese DFBD cases."

The objective of this study is to amass and catalog DFBD events and their related information as comprehensively as possible, with the aim of establishing a global DFBD dataset, which serve as a valuable repository of data and to provide a multidimensional perspective for DFBD research. Currently, this dataset represents a preliminary attempt, and while it has its limitations, it is relatively comprehensive and well-documented. And as Reviewer #3 pointed out, although the dataset contains a significantly larger number of Chinese DFBDs than those from other countries and regions, it still includes 179 DFBDs from various other locations. Given this, we believe it is acceptable to label this dataset as "global" in scope. This geographical bias does not impede the core objective of our study, which is to establish a comprehensive dataset of DFBDs while including as much related information as possible. Furthermore, it does not diminish the global value of our dataset.

Comment 5

In Figure 7, I understand that the authors aim to highlight some DFBDs using remote sensing imagery; however, I honestly cannot distinguish

the DFBDs from the surrounding areas. I recommend using higher-resolution imagery, such as data from Planet, which can provide resolutions as high as 1 to 3 meters.

Response 5

Thank you! Your recommendation to use higher resolution imagery data, such as data from Planet, is very insightful. Although we have used Planet's highest-resolution remote sensing imagery in Figure 7 of the original manuscript, we have enhanced the visual presentation of Figure 7 in the revised manuscript to ensure that the features of the DFBDs are more prominent and easily identifiable. ***(P27L574~581)***

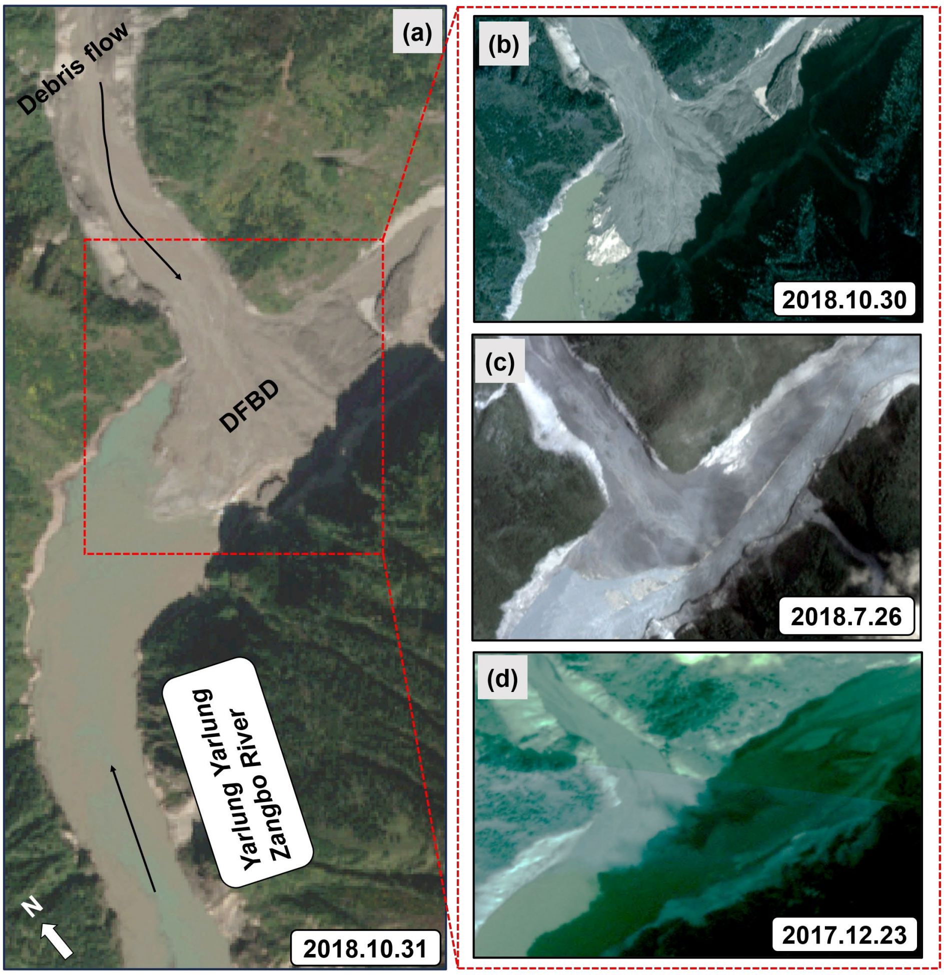

Figure. 8 Repeated DFBDs due to glacial debris flows generated in the Sedongpu catchment, upper Yarlung Tsangpo, eastern Tibet. (a) Remote sensing image after the events on October 17th and 29th, 2018 (October 31st, 2018); (b) remote sensing image after the event of October 17, 2018 (October 30, 2018); (c) remote sensing image of July 26, 2018; (d) remote sensing image after the event of December 22, 2017 (December

23, 2017). The remote sensing image (a) is sentinel-2 (https://dataspace.copernicus.eu/) and (b-d) are sourced from PlanetScope (https://www.planet.com/).
Comment 6 **When reviewing the dataset provided by the authors at https://doi.org/10.5281/zenodo.14766647, I have the following major concerns:** **(1) Many DFBDs (EFBD_ID 1 to 31) are listed in languages other than English. While I understand that translating or converting the names to English can be challenging, the authors are proposing a worldwide dataset. How can others utilize this data if the names are in languages like Taiwanese or Japanese (e.g., 姫川・大所川・赤禿)? After consulting with my Chinese colleague, I believe these names could be converted to English.**
Response 6 Thank you for your comment. We regret not completing this crucial step before submission. In response to your suggestion, we have unified the language in the dataset to English, and we have updated the dataset and re-uploaded the revised version to https://doi.org/10.5281/zenodo.14766647 for public and academic access.
Comment 7 **(2) Many DFBDs are missing data on important parameters such as debris flow channel slope gradient (%) and debris flow channel length (km). I highly recommend filling in these missing pieces of information before the dataset can be considered for publication.**
Response 7 Thanks for your suggestion. We have conducted a more thorough literature review and used remote sensing imagery to obtain the gradient and length of debris flow channels, as well as the area of debris flow gully basins. The updated dataset version has been uploaded to https://doi.org/10.5281/zenodo.14766647. In addition, we have saved

intermediate process files for obtaining data through remote sensing images, which are mainly stored in KMZ format and have been uploaded as supplementary files.
Comment 8 **The dam material information for several entries (EFBD_ID 3-33) is listed in Japanese. Please ensure this information is provided in English.**
Response 8 Thank you very much for your valuable feedback. We have unified the language in the dataset to English and have re-uploaded the updated version of the dataset (https://doi.org/10.5281/zenodo.14766647).

Reference:

Fan, X., van Westen, C. J., Xu, Q., Gorum, T., and Dai, F.: Analysis of landslide dams induced by the 2008 Wenchuan earthquake, Journal of Asian Earth Sciences, 57, 25-37, https://doi.org/10.1016/j.jseaes.2012.06.002, 2012a.

Fan, X., van Westen, C. J., Korup, O., Gorum, T., Xu, Q., Dai, F., Huang, R., and Wang, G.: Transient water and sediment storage of the decaying landslide dams induced by the 2008 Wenchuan earthquake, China, Geomorphology, 171-172, 58-68, https://doi.org/10.1016/j.geomorph.2012.05.003, 2012b.

Fan, X., Xu, Q., van Westen, C. J., Huang, R., and Tang, R.: Characteristics and classification of landslide dams associated with the 2008 Wenchuan earthquake, Geoenvironmental Disasters, 4, 12, 10.1186/s40677-017-0079-8, 2017.

Fan, X., Scaringi, G., Domènech, G., Yang, F., Guo, X., Dai, L., He, C., Xu, Q., and Huang, R.: Two multi-temporal datasets that track the enhanced landsliding after the 2008 Wenchuan earthquake, Earth Syst. Sci. Data, 11, 35–55, https://doi.org/10.5194/essd-11-35-2019, 2019.

Shi, Z. M., Wang, Y. Q., Peng, M., Chen, J. F., and Yuan, J.: Characteristics of the landslide dams induced by the 2008 Wenchuan earthquake and dynamic behavior analysis using large-scale shaking table tests, Engineering Geology, 194, 25-37, https://doi.org/10.1016/j.enggeo.2014.10.009, 2015.

Jiang, H., Zou, Q., Zhou, B., Hu, Z., Li, C., Yao, S., and Yao, H.: Susceptibility Assessment of Debris Flows Coupled with Ecohydrological Activation in the Eastern Qinghai-Tibet Plateau, 10.3390/rs14061444, 2022.

Zhou, Y., Hu, X., Xi, C., Wen, H., Cao, X., Jin, T., Zhou, R., Zhang, Y., and Gong, X.: Glacial debris flow susceptibility mapping based on combined models in the Parlung Tsangpo Basin, China, Journal of Mountain Science, 21, 1231-1245, 10.1007/s11629-023-8500-0, 2024.

Zhou, Y., Yue, D., Liang, G., Li, S., Zhao, Y., Chao, Z., and Meng, X.: Risk Assessment of Debris Flow in a Mountain-Basin Area, Western China, 10.3390/rs14122942, 2022.

The Response to Comments from Reviewer 2

Comment 1 **The paper presents a global debris-flow barrier dam dataset spanning from 1800 to 2023, which holds significant scientific value and practicality for the field of debris flow protection. The dataset encompasses a wide range of dam characteristics and debris flow parameters, combined with historical events and geographical distribution information, providing robust data support for future research and practical applications. Here are some suggestions to enhance the study.**
Response 1 Thank you very much for taking the time to review our paper and for providing such professional and constructive feedback. Your recognition of the global debris-flow barrier dam dataset we created has greatly inspired our entire team, significantly boosting our confidence and commitment to enhancing this dataset. You accurately pointed out the important scientific value and practical applications of this dataset. Your acknowledgment of its comprehensive range of information and potential to support future research and applications means a great deal to us. Receiving your validation of the dataset's uniqueness and significance is the most rewarding outcome of our extensive data collection and meticulous organization efforts.
Comment 2 **1、It is recommended that the paper includes detailed metadata about the dataset, specifying the sources, collection, and validation methods of the data. Particularly, information regarding climatic and environmental factors could further enhance the applicability of the data.**
Response 2 We greatly appreciate the constructive suggestions you have provided, which

has been immensely helpful in enhancing the quality of our manuscript. We have refined the sources, collection, and validation methods of our data in the revised manuscript (please refer to Section 2: Data and Method) ***(P6~19L139~372)***. In addition, we have saved intermediate process files for obtaining data through remote sensing images, which are mainly stored in KMZ format and have been uploaded as supplementary files.

Furthermore, your mention of climatic and environmental factors has been a significant inspiration for us. We recognize the importance of these data in understanding the formation and development of DFBDs. We have supplemented the precipitation and temperature information in our dataset (pleases see https://doi.org/10.5281/zenodo.14766647). And, in Section 2 of the revised manuscript, we have detailed the data sources and collection methods for precipitation and temperature information. ***(P16L305~313)***

"- ***Precipitation*** and ***Temperature.*** Fick and Hijmans (2017) established a global historical climate dataset, which was updated in January 2020. Their dataset includes monthly average precipitation and temperature data from 1970 to 2000, with a spatial resolution of 30 seconds (approximately 1 km^2). In our study, for DFBDs formed between 1970 and 2000, we extracted the corresponding precipitation and temperature data from the dataset of Fick and Hijmans (2017) and associated these data with the respective DFBD cases. For DFBDs formed outside the period of 1970 to 2000, we did not include the precipitation and temperature data."

Thank you once again for your valuable comments.

Comment 3

2、Providing the data analysis tools and algorithms used would facilitate readers in understanding the specific steps and methods of data processing, enhancing the reproducibility of the study.

Response 3

Thank you for your suggestion. We mainly obtained information about DFBDs through literature review and news reports, etc. We have provided the reference of each case in the dataset. In the revised manuscript, we have added a detailed description of the data acquisition and analysis tools we used in Section 2.4 “Data analysis tools”. ***(P18~19L362~372)***

“In the process of constructing and analyzing this dataset, we integrated a variety of tools to ensure the efficiency of our work and the accuracy of the data. First, we rigorously validated the data using Google Earth and preserved the intermediate process files obtained through remote sensing imagery in their entirety. These files, stored in KMZ format, have been uploaded as supplementary materials for future reference and verification. Additionally, we utilized ArcMap 10.8 software to extract temperature and precipitation data and completed the relevant charting tasks. In the data processing phase, we primarily used Excel for data organization and analysis, and employed Origin software to create clear and accurate data charts that intuitively present our research findings.”

Comment 4

3、A detailed explanation of the sources and validation processes for each data item in the dataset is advised, especially for data obtained from news reports. The accuracy of these data may vary due to regional and source differences.

Response 4

Thank you very much for your valuable suggestions and professional insights. We fully agree with your perspective that the data sources and validation processes are essential for ensuring the reliability and accuracy of our research, particularly when dealing with data derived from news reports. To response your recommendations, we have enhanced the documentation of data sources and validation procedures in the revised manuscript, especially for data obtained from news reports. ***(P18L348~360)***

“The third step is data complementation. In the situations when there is conflicting information among different data sources, we have adopted a hierarchy of information sources based on perceived reliability to resolve the issue: priority was given to literature published in journals with higher impact factors, as these data have undergone peer review and are of high reliability and authority; next were publications in journals with lower impact factors; and then, we referred to news reports published on official government websites, which are accurate and timely due to their official certification; in very few cases, when there were no data from the above sources, we referred to reports from non-government media. In our dataset, the number of cases obtained from non-government media is minimal, accounting for less than 1% of the total. According to this priority rule, we have incorporated the conflicting information into our dataset to ensure the accuracy and reliability of the data."

Comment 5

4、While the paper offers a global dataset, it is crucial to ensure that the findings are universally applicable, especially under varying geographical and climatic conditions. This may require additional analysis or disclaimers regarding the limitations of the dataset in different global contexts.

Response 5

Thank you for your suggestion. We have included disclaimers in the revised manuscript. ***(P39L872~875)***

"The case samples in this dataset are distributed globally, and there may be limitations in applicability under certain specific geographical or climatic conditions. Readers are advised to be aware of these limitations when using the data."

Comment 6

5、The paper discusses the applicability of existing landslide dam (LD) stability models and peak discharge models to debris-flow barrier dams (DFBDs). Does the paper sufficiently consider the limitations of these

models and clearly point out them in the results.
Response 6 We appreciate your comment. We have detailed the limitations of these stability models and peak discharge models in the revised manuscript. "In fact, the stability of a dam depends on the characteristics of the dam itself (Ashraf et al., 2021; Costa and Schuster, 1988; Latrubesse et al., 2020), such as the geotechnical properties of the dam (Fan et al., 2020; Pisaniello et al., 2015; Schuster, 2000;). The empirical models are often parameter models derived from historical statistical cases, which are limited in number and often fail to cover all types, all geographical environments, and all formation conditions of barrier dams. Barrier dams in different regions and with different causes have their own unique characteristics. For example, LDs and DFBDs differ significantly in material structure and formation mechanisms. Therefore, the predictive validity of the BI, II, and I_e models is significantly reduced. We believe that it is necessary to meticulously categorize barrier dams according to their formation mechanisms, and to expand the existing database by increasing the number of case studies. This is precisely the original intention behind the establishment of this dataset." ***(P31L641~654)*** "The peak discharge models in Table 5 were derived from the statistics of historical events. Their sample size was limited, and them ignored the failure mechanism and the geotechnical properties of dams, and did not strictly distinguish between different types of barrier dams. As a result, their prediction accuracy was affected by the region and the type of dam. Therefore, the models in Table 5 are difficult to be used for predicting the peak discharge of DFBDs (Fig.10). Establishing a peak discharge model suitable for DFBDs is a key issue to be solved in the future. This dataset can provide rich cases and basic data to help solve this problem." ***(P33L686~694)***

Reference:

Ashraf, A., Iqbal, M. B., Mustafa, N., Naz, R., and Ahmad, B.: Prevalent risk of glacial lake outburst flood hazard in the Hindu Kush-Karakoram-Himalaya region of Pakistan, Environmental Earth Sciences, 80, 2021.

Costa, J. E. and Schuster, R. L.: The formation and failure of natural dams, Geological Society of America Bulletin, 100(7), 1054-1068, 1988.

Fan, X., Yang, F., Siva, S. S., Xu, Q., Feng, Z., Mavrouli, O., Peng, M., Ouyang, C., Jansen, J. D., and Huang, R.: Prediction of a multi-hazard chain by an integrated numerical simulation approach: the Baige landslide, Jinsha River, China. Landsides, 17(1), 147–164, 2020.

Latrubesse, E. M., Park, E., Sieh, K., Dang, T. D., Lin, Y. N., and Yun, S.: Dam failure and a catastrophic flood in the Mekong basin (Bolaven Plateau), southern Laos, 2018, Geomorphology, 362, 107221, 2020.

Pisaniello, J. D., Dam, T. T., and Tingey-Holyoak, J. L.: International small dam safety assurance policy benchmarks to avoid dam failure flood disasters in developing countries, Journal of Hydrology, 531, 1141-1153, 2015.

Schuster, R. L.: Dams built on pre-existing landslides. In: GeoEng 2000 – Geotechnical and Geological Engineering: International Society for Rock Mechanics and Rock Engineering. 19-24 November 2000, Melbourne, Australia. pp. 1537–1589, 2000.

The Response to Comments from Reviewer 3

Comment 1

The authors have successfully constructed a dataset covering 555 DFBD events worldwide from 1800 to 2023. This is the first dataset in this field specifically targeting DFBDs, filling the gap in the systematic data integration of DFBD events in existing research. Therefore, this study is innovative.

The authors have ensured the richness and diversity of the data by integrating multiple data sources, including academic literature, data from government agencies, proceedings of professional conferences, and reports from authoritative news media, totaling 2,519 data sources. Moreover, the dataset provides references on the sources of case data, and this dataset has been made public on Zenodo, which increases the transparency and repeatability of this study. The data collection process was comprehensive and systematic. Additionally, the data processing steps were rigorous. Therefore, it can be considered that the methods of data collection and processing in this paper are reasonable.

My judgment is that this is an innovative work in this field, which is of great significance for understanding and predicting the formation, distribution, and evolution of DFBDs.

This dataset provides valuable basic data and perspectives, contributing to a certain extent to research in this field. However, there are still some aspects that need to be improved in this paper.

Response 1

We are extremely grateful for your comprehensive and in-depth review and the high praise you have given to our research work on constructing the global debris-flow barrier dam dataset. Your detailed comments make us feel deeply honored and highly encouraged, and at the same time, provide us

with valuable directions for further improving our research. We will, in accordance with your suggestions, further enhance the quality of this work. Thank you again for your precious time, professional suggestions and appreciation.
Comment 2 **1、The introduction part needs to further summarize and analyze the research status.**
Response 2 Thank you very much! We have further deepened the summary and analysis of the current research status, which can be found in Section 1 "Introduction" of the revised version. ***(P2~5L47~138)*** "Debris flows, composed of fine and coarse-grained components, boulders, woody, and water, are a rapid two-phase flow with non-zero yield stress (Hungr et al., 2014). When debris flows carry large amounts of sediment flowing rapidly in a valley, they may accumulate in a narrow river channel and form a barrier dam, that is, debris-flow barrier dam (DFBD) (Fan et al., 2020; Yin et al., 2016; Yu et al., 2022; Zhang et al., 2022). The formation of such barrier dams not only changes the original hydrogeological conditions, but may also results in secondary disasters, such as floods, landslides, and even larger debris flows, posing a serious threat to human society and the natural environment (Cui et al., 2016; Gouli et al., 2025; Hu et al., 2011; Liu et al., 2019). For example, on August 7, 2010, triggered by heavy rainfall, a large-scale debris flow broke out in Luojiayu and Sanyanyu Gully in Zhouqu County, China. After the debris flow passed through Zhouqu City, it blocked the Bailong River (Fig.1). The water level in the upper reaches rose sharply, which submerged half of Zhouqu City, resulting in 1364 casualties and 401 missing (Chong et al., 2021; Hu et al., 2010).

Figure. 1 Post-disaster images of the Zhouqu debris flow. (a) The debris flow rushed into the Bailong River, forming a submerged dam; (b) Blasting operations on the debris flow barrier dam to accelerate discharge. The images are from China News Service (https://www.chinanews.com.cn/).

Compared with LDs, DFBDs possess unique characteristics, with differences primarily manifested in dam geometry, material composition, and internal structure. In terms of dam geometry, DFBDs have lower heights and gentler upstream and downstream slopes than LDs (Cheng et al., 2007a, 2007b; Dang et al., 2009). Regarding material composition, the materials of DFBDs have a near-saturated water content, which is significantly higher than that of LDs (Cheng et al., 2007a, 2007b; Dang et al., 2009; Wang et al., 2017). Moreover, DFBDs have a higher clay content (Dang et al., 2009; Liu et al., 2014) and high-rounded particles compared to LDs (Dang et al., 2009). In terms of internal structure, DFBDs are more compact, with poorer grain sorting and lower permeability (Dang et al., 2009; Liu et al., 2014). These differences result in distinct stability and failure characteristics for DFBDs compared to LDs (Ruan et al., 2021).

Currently, researches on DFBDs mainly focus on a single event (Hu et al., 2010; 2011), or physical and numerical experiments conducted with a single event as the prototype, focusing on the research of river obstruction by debris flows (Chen et al., 2022; Dang et al., 2009; Ruan et al., 2021). In terms of properties and scale, debris flows that form barrier dams are typically large-scale and cohesive, with high density and uniformity, exhibiting considerable resistance to erosion (Chen et al., 2019; Ruan et al., 2021). In terms of topography, the rivers and valleys blocked by DFBDs are generally narrow, with steep terrain slopes (Song et al., 2023; Wang et al., 2017; Yu et al., 2022).

Isolated studies of individual DFBD events cannot reflect the overall distribution characteristics. However, statistical analysis of a great number of historical data on barrier dam disasters can help to clarify this issue. Some scholars have conducted extensive researches on parameters such as geometric characteristics, breaching, longevity, and stability of barrier dams by establishing datasets (Casagli et al., 2003; Dong et al., 2014; Fan et al., 2012; 2017; Peng and Zhang, 2012a; b; Stefanelli et al., 2015; 2016). However, there are relatively few cases of DFBDs in these datasets. The conclusions drawn from these barrier dam datasets may not be applicable to DFBDs. Therefore, there is an urgent need to establish a global comprehensive dataset specifically for DFBDs, laying a data foundation for in-depth research on such dams in the future, which is one of the goals of this study.

After the formation of a barrier dam, timely predictions of the stability of the dam and the outburst peak discharge are the keys to formulating disaster reduction measures, and it are also hot topics in barrier dams-related researches (Azimi et al., 2015; Casagli and Ermini, 1999; Korup, 2004). Based on the statistical analysis methods, some scholars analyzed the influence of dam structure characteristics, dam material characteristics, hydrological characteristics, and other factors on the stabilities of dams, and established some models for evaluating barrier dam stability (Dong et al., 2011; Ermini and Casagli, 2003). Other studies based on historical statistical cases, summarized parameter models for the peak discharge, in order to achieve rapid prediction of peak discharge of barrier dam breach (Azimi et al., 2015; Hakimzadeh et al., 2014; Hooshyaripor et al., 2014). However, these studies did not strictly differentiate the barrier dams, focusing more on

LDs. Considering that DFBDs have unique characteristics compared to LDs (Cheng et al., 2007a; b; Dang et al., 2009; Ruan et al., 2021), the applicability of stability and peak discharge models, originally designed for LDs, to DFBDs remains unclear. This constitutes the second key issue to be explored in this study. This study establishes a dataset containing 555 DFBDs worldwide by exploring 2519 literatures and media reports. This dataset contains information of DFBDs on the formation time, location, geometric characteristics, longevity, peak discharge, failure characteristics, blockage modes, failure mechanisms, stability, loss of life, etc. A detailed analysis was conducted on the spatiotemporal distribution, blockage modes, failure mechanisms, longevity, and stability of DFBDs. The applicability of stability and peak discharge models, of LDs, for DFBDs was discussed. Compared with other datasets, our dataset stands out for its emphasis on the unity of terminology and concepts, as well as the review and validation of raw data, to ensure consistency and accuracy of the data."
Comment 3 **2、Figure 4 is missing the title for (c).**
Response 3 Thank you for your meticulous review. We have added a title to Figure 4(c) and have also corrected the title of Figure 4(b). ***(P20L404~406)***

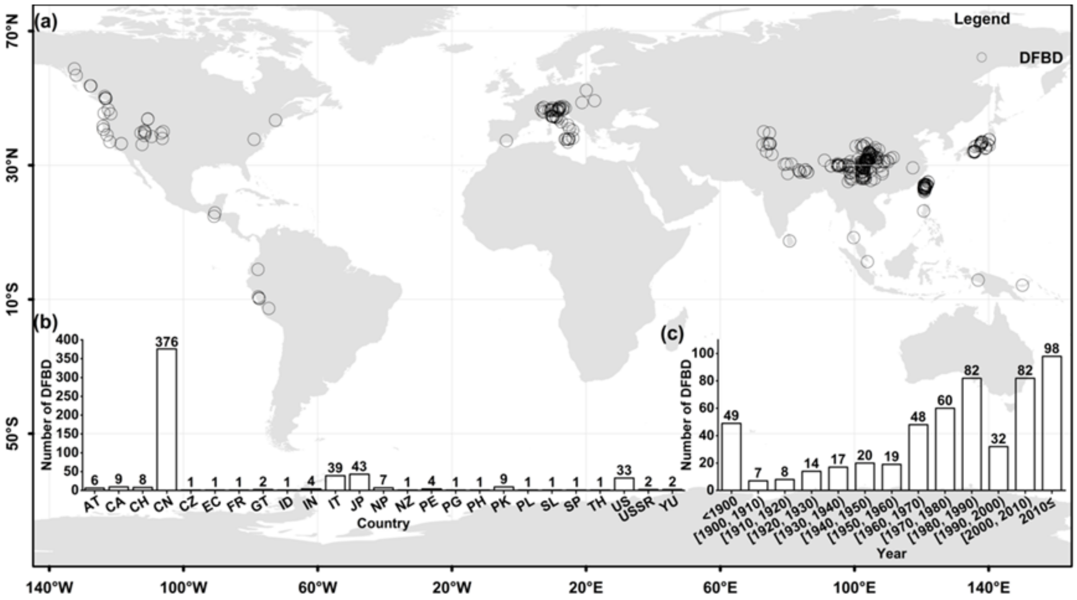

Figure.4 Worldwide DFBDs spatiotemporal distribution. (a) Spatial distribution; (b) the number of DFBDs in each country; (c) temporal distribution.

Comment 4

3、The authors have pointed out the phenomenon of repeatedly river blockage by DFBDs, which is an important and interesting finding. It is recommended to further explain the causes and consequences of this phenomenon.

Response 4

Thank you for your insightful comment on our manuscript. We have supplemented the causes and consequences of the phenomenon of repeated river blockages by DFBDs in Section 3.5, titled “The phenomenon of repeated river blockages,” of the revised manuscript. ***(P25~26L529~546)***

“Some debris flow gullies, due to the presence of a large amount of loose material within their basins, repeatedly experienced debris flows triggered by factors such as rainfall, causing river blockages (Hu et al., 2019; Zhang et al., 2022). Alternatively, after a debris flow event, a significant amount of material on the slopes along the gully remained in a loosely cemented state, which can easily be remobilized into the main channel by heavy rainfall, leading to multiple river blockages and dam formations (Wang et al., 2022). The repeated formation of DFBDs significantly increased their hazard potential. The hazards associated with DFBDs were mainly manifested in four aspects: (1) upstream inundation caused by the DFBDs (Hu et al., 2022; Rizzo et al., 2023; Taylor, 2023; Wang et al., 2015); (2) downstream abnormal flood disasters caused by the failure of DFBDs (Takayama et al., 2021; Veh et al., 2020; Yang et al., 2022); (3) sedimentation in downstream river channels caused by the outflow or failure of DFBD, leading to riverbed aggradation and reduced flood conveyance capacity of the river channels (Cao et al., 2011; Vázquez-Tarrío et al., 2024); and (4) the high risk of the residual dam material transforming into debris flows under heavy rainfall after the DFBD has released its impounded water (Chen et al., 2022)."

Comment 5

4、Based on the DFBD dataset, the authors further discussed the applicability of existing landslide barrier dam stability models and peak discharge models to debris-flow barrier dams, which is a meaningful exploration. It is suggested that the authors further summarize the limitations of these models and potential directions for improvement.

Response 5

We are truly grateful that you have taken the precious time to review our manuscript and provided highly constructive and inspiring comments. You suggested that we further summarize the limitations of the existing stability models and peak discharge models as well as the potential directions for improvement, which is crucial for improving our research.

1. According to your suggestions, we have supplemented the limitations of the empirical stability models and the potential directions for improvement in Section 4.1, titled "Applicability of LD stability models to DFBDs", in the revised manuscript. ***(P31L641~654)***

"In fact, the stability of a dam depends on the characteristics of the dam itself (Ashraf et al., 2021; Costa and Schuster, 1988; Latrubesse et al., 2020), such as the geotechnical properties of the dam (Fan et al., 2020; Pisaniello et al., 2015; Schuster, 2000). The empirical models are often parameter models derived from historical statistical cases, which are limited in number and often fail to cover all types, all geographical environments, and all formation conditions of barrier dams. Barrier dams in different regions and with different causes have their own unique characteristics. For example, LDs and DFBDs differ significantly in material structure and formation mechanisms. Therefore, the predictive validity of the *BI*, *II*, and I_e models is significantly reduced.

We believe that it is necessary to meticulously categorize barrier dams according to their formation mechanisms, and to expand the existing database by increasing the number of case studies. This is precisely the original intention behind the establishment of this dataset."

2. We have added the limitations of the empirical peak discharge models and the directions for future efforts in Section 4.2, titled "Applicability of LD peak discharge models to DFBDs", in the revised manuscript. ***(P33L686~694)***

"The peak discharge models in Table 5 were derived from the statistics of historical events. Their sample size was limited, and them ignored the failure mechanism and the geotechnical properties of dams, and did not strictly distinguish between different types of barrier dams. As a result, their prediction accuracy was affected by the region and the type of dam. Therefore, the models in Table 5 are difficult to be used for predicting the peak discharge of DFBDs (Fig.10). Establishing a peak discharge model suitable for DFBDs is a key issue to be solved in the future. This dataset can provide rich cases and basic data to help solve this problem."

Comment 6

5、The format of the reference in line 743, 'Costa, J. E. and Schuster, R. L.: The formation and failure of natural dams, Geological Society of America Bulletin, 100(7), 1054-1068, 1988.', seems to be incorrect.

Response 6

Thank you for your attention to the reference format in the manuscript. We have corrected the citation format for this reference. ***(P42L937~938)*** "Costa, J. E., and Schuster, R. L.: The formation and failure of natural dams, Geological Society of America Bulletin, 100(7), 1054-1068, 1988."
Comment 7 **6、It is recommended that the authors unify the language in the dataset to English to facilitate readers in reading and accessing the data.**
Response 7 Thank you very much for your meticulous review. We have reviewed all entries in the dataset and translated non-English entries into English to ensure the consistency of the dataset. Furthermore, we have updated the revised dataset on Zenodo.
Comment 8 **7、The authors claimed that this is a worldwide dataset. However, the number of DFBDs in China in the dataset was much greater than that in other countries and regions. Considering that there are still 179 DFBDs in other countries and regions in this dataset and the value of these data themselves, I think it is acceptable to name this data on a 'worldwide' scale. Nevertheless, it is recommended that the authors supplement the reasons for the large number of DFBDs in China in this dataset. Alternatively, in Section 4.4 'Limitations in this work,' the authors should discuss the spatial distribution limitations of the DFBDs included in the dataset and outline plans for future research.**
Response 8 Thank you for your suggestion, and we fully agree with your perspective. In fact, in Section 3.2 of our original manuscript, we have already explained the reasons for the large number of Chinese DFBDs in the dataset. Following your advice, we have supplemented the reasons for the high number of

Chinese DFBDs in Section 3.2 “Spatiotemporal distribution of the DFBDs” of the revised manuscript. ***(P20~21L407~435)***

“The number of Chinese DFBDs in the dataset is significantly high, which can be mainly attributed to the following reasons. (1) Active geological activity: China is located at the junction of multiple tectonic plates, with complex geological structures and active neotectonic movements, leading to frequent earthquakes. Earthquakes cause rock fragmentation and mountain loosening, producing a large amount of loose soil and stone, providing a rich source of material for the formation of debris flows. For example, after the 2008 Wenchuan earthquake, a large number of debris flow dam events occurred in the earthquake-affected area and its surroundings (Fan et al., 2012a; b; 2017; 2019; Shi et al., 2015). (2) Diverse climatic conditions: China has a rich variety of climate types, with a significant monsoon climate and concentrated rainfall, often in the form of heavy storms. In some mountainous areas, intense rainfall over a short period can rapidly increase surface runoff, carrying a large amount of silt, rocks, and other materials to form debris flows. Additionally, in high-altitude glacial regions, the melting of glaciers and snow due to rising temperatures in summer can also provide ample water sources for debris flows, promoting the formation of debris flow and DFBDs. (3) Complex topography and geomorphology: China has a vast mountainous area with significant terrain undulations, crisscrossing valleys, and notable elevation differences. Especially in the western and southwestern regions, such as the edges of the Tibetan Plateau (Jiang et al., 2022; Zhou et al., 2024) and the Hengduan Mountains (Zhou et al., 2022), the high mountains and deep valleys with steep slopes and rapid streams provide favorable topographical conditions for the formation of DFBDs (Fig.6(a)). A large amount of loose solid material is prone to accumulate in valleys, and once triggered by an appropriate water source, it is easy to form debris flows that can dam rivers and create DFBDs. Although other countries like Japan frequently experience debris flows, there are few topographical conditions, such as deep valleys and high relief, that are conducive to the formation of debris flow dams; therefore, there are fewer DFBDs in Japan."

Comment 9

8、In view of the fact that the construction of the dataset is an ongoing process, it is recommended that the authors continue to refine and update the dataset in future work.

Response 9

Thank you very much for your valuable suggestions and support for our research. We completely agree with your perspective that the construction of the dataset is indeed an ongoing process that requires continuous refinement and updating. We plan to take the following measures in our future research:

Continuous Updating: We will regularly review and update the dataset to include the latest research findings and discoveries, ensuring the timeliness and relevance of the dataset.

Data Quality Control: We will continue to conduct strict quality control on the dataset to ensure the accuracy and reliability of all entries.

Collaboration and Sharing: We encourage collaboration with peers to share data and resources in order to jointly advance research in this field.

Technological Advancements: With the development of technology, we will explore new tools and methods to enhance the functionality and user experience of the dataset.

We are committed to incorporating these measures into our future work plans and continuously optimizing the dataset. Once again, thank you for your suggestions, which are of great significance to improving the quality of our research and the practicality of the dataset.

Comment 10

9、Can the author supplement the gradation parameters of debris flow barrier dam?

Response 10

Thank you for your insightful comments. We acknowledge that the gradation parameters are crucial for a comprehensive understanding of the characteristics and behavior of the dams. However, collecting information on the gradation parameters for DFBDs is indeed a challenging task. At present, we have only identified a very limited number of DFBD case studies with gradation parameters information, which still requires our long-term continuous improvement. Moreover, this information is highly relevant to our current research work. After discussion among all co-authors of this paper, we have decided to share the gradation parameters information of DFBDs in our future research.

Comment 11

10、It is suggested that the author further explains how to define the ' stability ' of the debris flow barrier dam? Because the structure of the debris flow dam is very stable.

Response 11

Thank you for your comment. We have added the definition of stability in the revised manuscript, see section 3.4 “Stability and longevity”. ***(P24L489~504)***

“Current empirical classification schemes for barrier dam stability, developed by Ermini and Casagli (2003), Korup (2004), and Tacconi Stefanelli et al. (2016), trace back to the original definition by Casagli and Ermini (1999). This initial concept was limited to barrier dams that had either catastrophically failed or remained intact. In these studies, stability refers to the instantaneous state of the dam and the dammed lake at the time of inspection, without factoring in the length of time the dam has remained unfailed (longevity). According to this definition, a barrier dam is considered stable if the dammed lake is still present or has been filled with sediments during the analysis. The latter scenario implies that the dam was capable of holding back the lake water (either by maintaining an in - and outflow balance through seepage or spillway flow) and enabled continuous sediment deposition in the lake until it was silted up.Conversely, dams classified as "unstable" have experienced catastrophic breaching. Evidences of such include deep gullies, an impoundment with little sediment, erosional signs in the remaining sediments suggesting rapid water drawdown, and flood - deposited sediments downstream (Fan et al., 2020)."

The assessment of stability is a complex process, which not only involves the structural stability of the dam body but also includes the dynamic interactions between the dam and the dammed lake water flow (Tacconi Stefanelli et al., 2016). Therefore, the stability of the dam structure and the stability of the dam itself are two different concepts. To sum up, the fact that the structure of the DFBD is very stable does not mean that the DFBD is stable.

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