Dear Prof. Wilfried,

We sincerely thank you for your thoughtful and constructive suggestions on our manuscript "*Brief communication: A landslide-induced winter outburst from a frozen glacial lake in the Central Himalaya*." We greatly appreciate your recognition of the scientific value of this case study and your encouraging assessment that it is "perfectly suited as 'brief communication' in The Cryosphere." Your comments have been invaluable in improving the clarity and impact of our work.

Below, we provide our point-by-point responses to your comments. All revisions have been made in the revised manuscript with changes highlighted.

Reply to Prof. Wilfried

General:

The submitted manuscript describes an interesting case of a large winter rock-ice avalanche from a steep, lateral, glacially de-buttressed permafrost rock slope, partially onto a glacier and partially into a lake with a thick lake ice cover. Even though the event did not cause grave damage, the documentation of the involved lake-ice damping effects and "lake ice tsunami" is an important contribution to the ongoing learning process about increasing hazards and risks from rock-ice avalanches into lakes events at other sites worldwide.

We thank you for your positive assessment of our work. We are pleased that you also suggested the importance of documenting this unprecedented winter event and its implications for understanding lake-ice damping effects and impulse wave dynamics.

The authors may wish to more clearly emphasize the cold-dry climatic conditions of this Tibetan region, with largely continuous permafrost in moraines and rock walls probably reaching to depths of up to hundred meters and more.

We agree that this is an important contextual point. In the revised manuscript, we have added explicit emphasis on the cold-dry climatic conditions of the study region and the permafrost characteristics. Specifically:

In Section 2 (lines 74-76 in revising version), we have expanded the description of climate in this region:

" It is a highly permafrost-affected catchment, with mean annual air temperatures below -3.6°C and average relative humidity of about 40%, characterized by the cold-dry

climate zone in the Central Himalaya (Banerjee and Sati, 2026)."

In Section 4 (lines 169-171 in revising version), we have strengthened the connection between glacier retreat, permafrost degradation and rock failure:

"The rock slope failure occurred in a permafrost-affected bedrock wall that has been progressively de-buttressed by glacier retreat. The cold-dry permafrost conditions in this region make rock slopes particularly susceptible to thermal-mechanical stress changes during rapid temperature fluctuations."

The presented case study provides interesting and useful information about hardly ever considered aspects related to impulse waves in lakes and induced down valley floods. It is perfectly suited as a "brief communication" in The Cryosphere. The observations and reconstructions of the event with its cascading processes are well described. The formulations may in places need some smoothing. Related minor technical comments and recommendations are listed below.

We are grateful for this encouraging endorsement. We have maintained the concise format appropriate for brief communication while ensuring all key observations and implications are clearly presented. Thank you for this positive feedback on our observational and methodological approach.

Minor remarks:

Line 18 : broke (not broken)

Revised.

Lines 22/23: Better perhaps " ··· occurrence window of GLOFs in high mountain areas relates to all seasons, and winter events onto frozen lakes may even become more frequent as climate-induced paraglacial slope failures tend to increase in number".

Revised as your suggestion.

Lines 23/24: This is not a general "blind spot" in science, therefore better write something like: "This single event concerns an often ignored or underestimated winter aspect related to hazards from expanding or newly forming glacial lakes."

Revised as your suggestion.

Lines 34-36: Better eliminate "the strategy of mitigation preparation". This is not straightforward and would need further explanation.

Removed as your suggestion.

Line 38: Better “globally reported”.

Revised as your suggestion.

Line 43: Better “represented in red” than “texted with red”?

Revised as your suggestion.

Line 49: Better “exact timing”

Revised as your suggestion.

Line 57: Better “meeting”, “which meet”, “accompanied by” or the like (sentence otherwise incomplete)

Revised as your suggestion using “meeting”.

Line 61: The presented case study indeed documents strong damping effects. This could be more strongly emphasized.

We thank the reviewer for highlighting this point. The damping effects of lake ice are indeed one of the most significant and novel aspects of this case study, with important implications for GLOF hazard assessment. We have strengthened the emphasis on this finding in several places.

In section 4 (Trigger and chain process), we have added quantification of the damping effect:

“The ~0.35 m thick ice cover on Pida Lake absorbed a substantial portion of the rock avalanche's kinetic energy through ice fracture, fragmentation, and the dissipation of impact-generated waves beneath the frozen surface. Field observations of shattered ice plates and stranded ice blocks elevated up to 10 m above the lake surface attest to the energy dissipation that occurred. Based on the observed wave amplitude (~8-10 m) relative to the dam freeboard (~13-15 m), we estimate that the ice cover reduced the impulse wave amplitude by approximately 60-70% compared to an ice-free scenario. Without this damping effect, the wave would likely have overtopped the moraine dam catastrophically, potentially triggering a much larger outburst flood and compounding the failure of adjacent Longbasaba Lake. This case thus provides rare empirical evidence that lake ice, even when relatively thin (~0.35 m), can serve as an effective natural buffer against rockfall-induced GLOFs—a finding that has been hypothesized but rarely documented in the field.”

In section 5 (Lessons and implications), we have strengthened the concluding statement regarding lake ice damping in the final paragraph:

"The damping effect of lake ice, as demonstrated in this case, represents a double-edged sword for hazard assessment: while it can mitigate the immediate impact of rockfalls, it also masks the underlying threat by preventing the visible lake-level fluctuations that typically trigger GLOF warnings. This underscores the need for monitoring approaches that can detect sub-ice disturbances, rather than relying solely on surface observations."

We believe these revisions substantially strengthen the emphasis on the damping effects documented in this case study, which we agree is one of central contributions of this work. Thank you again for highlighting this important point.

Line 63: Better " … here we report …"

Revised as your suggestion.

Line 66/67: There is no need for an "alert" (the scientific community does not "ignore" the described phenomena) but rather a need to raise awareness about the described phenomena.

Revised as your suggestion using "raise awareness".

Line 72: Eliminate "were" ("occurred" alone is fine).

Removed.

Line 74: The authors could even write " … a perennially frozen lateral moraine collapse". The phenomenon of permafrost at South Lhonak was of fundamental importance for our understanding of the observed coherent flow fields, related stability conditions and involved volumes before the final event. The moraines in the here described region are most likely all frozen to large depths. This must have strong effects not only on slope stability but especially also on river erosion. As the outlet of Pida lake was artificially excavated (to what depth?), frozen ground may have been encountered.

Thanks for your suggestions. We have revised the description of the South Lhonak event to explicitly highlight the permafrost context:

"The most recent incident was the catastrophic failure of South Lhonak Lake in October 2023, located just on the east side of the Geiqu in India's Sikkim, triggered by a collapse of frozen lateral moraine (Sattar et al., 2025; Zhang et al., 2024b). The frozen state of the moraine was fundamental to the observed coherent flow fields and the stability conditions preceding the final failure, underscoring the critical role of permafrost in such high-mountain hazard cascades."

We have also added details regarding the artificial channel excavated in 2005 to lower

the lake level.

"Since 2006, local governments have implemented engineering measures to lower both lakes' levels, including the excavation of an artificial outlet channel across the Pida Lake end moraine in 2005. The channel, approximately 250 m in length and cut to a depth of 3-5 m below the original moraine crest, was designed to maintain the lake level below a critical threshold. During excavation, frozen ground conditions were encountered within the moraine, consistent with the region's permafrost environment, which may have influenced the channel's stability and long-term erosion resistance."

By the way, since in 2026 the EWS was already set up, we have also modified the text to mention the updates (Line 97-99 in revising version).

Line 77: Better "glacier-contact lakes". In fact, these lakes are probably also in contact with periglacial permafrost.

Revised as "glacier-contact lakes". Yes, these lakes are probably also in contact with periglacial permafrost, but here we just want to emphasize that these two lakes are experiencing rapid calving retreat as the proglacial lake growth.

Line 83: Better "in the southern Tibetan plateau"

Revised as your suggestion.

Line 95/96: Perhaps better: " ··· sudden increase in water level and turbidity together with drifting river ···"

Revised as your suggestion.

Line 116: Better "rock-ice avalanche" (as the event detaches from permafrost, it almost certainly contains ice)

Revised as your suggestion.

Line 121: Better "This toe landslide induced calving of about 2700 ···"

Revised as your suggestion.

Lines 123-125: The sequence of the statements could be improved, for instance: "The second landslide occurred in the late afternoon of 16 December. A volume of 4.29Mm3 collapsed from the upper part of the same glacially de-buttressed permafrost slope, leaving a distinct scarped edge line on the cliff wall. An estimated part of ~2.86 Mm3 of this rock-ice avalanche directly struck the frozen lake. This impact generated a sub-ice impulse wave that fractured the ~35 cm thick lake ice, producing an "ice tsunami" with ~10 m run-up, and triggered a down valley flash flood (see discussion below).

Modified as your suggestion.

”Lines 138 and 139 : Better “rock mass”

Revised as your suggestion.

Line 173: Perhaps better: “ ··· causes flood. As evident from the described case, a thick lake ice cover can exert a strong damping effect on the induced impulse wave.”

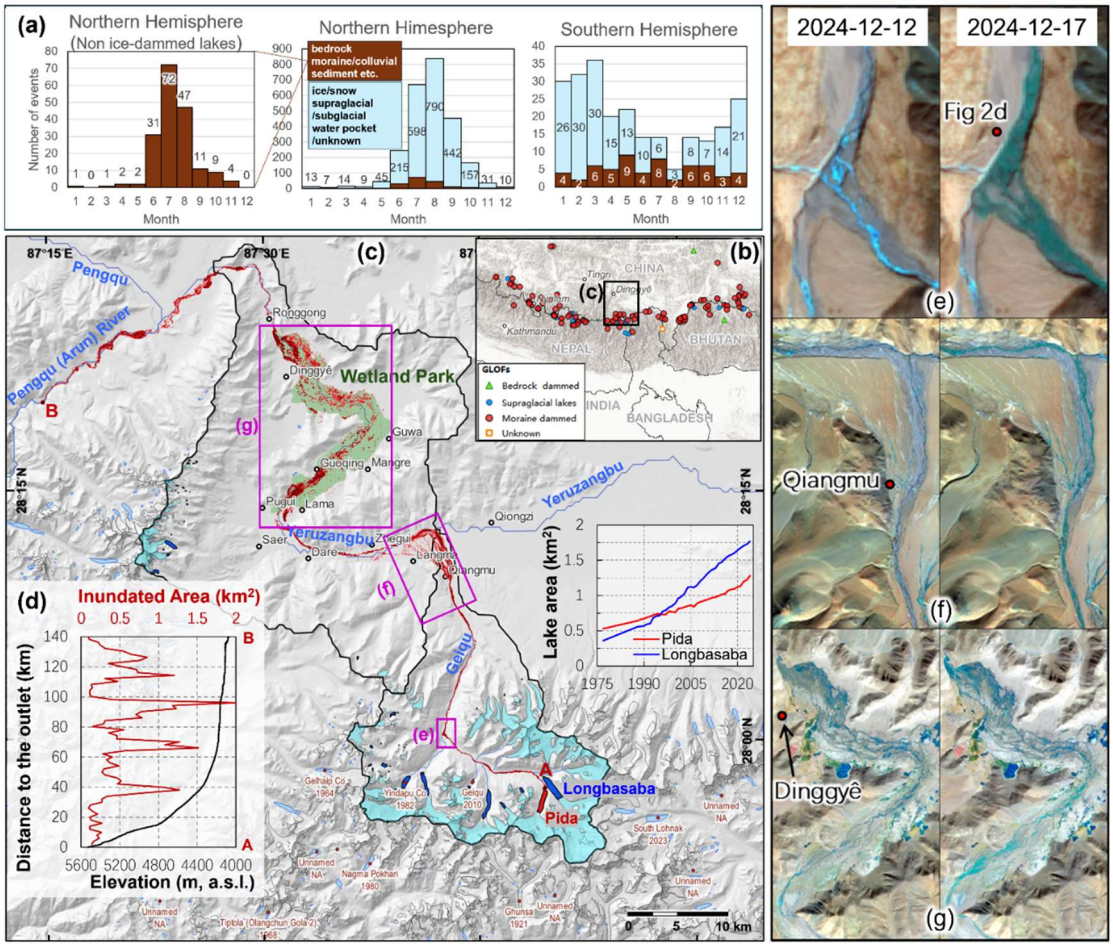
Revised as your suggestion.

Lines 181- 184: Better avoid over-emphasizing the importance of the observed aspects. Perhaps better write something like: “ ··· should adequately include lake-ice monitoring as part of early-warning systems in connection with possible winter GLOFs. This could directly be followed by the very last sentence: “Since water-pressure-based sensors often become non-operational when a lake freezes, new sensing technologies or strategies are needed to monitor real-time lake and ice disturbances and integrate these into GLOF early warning systems.” The quite general text in between could be eliminated without loss of essential information.

Thanks for your suggestion. We have reorganized the text as your suggestion.

Figures: The complex multi-graphs and multi-images, particularly in Fig. 1, contain rich information. This information, however, is hard to read due to the small individual sizes/fonts of the partial graphs and images. A re-arrangement, for instance through making two figures out of one, could help.

We have improved Figure 1 to enhance the text presentation. Due to the limitation of figure numbers of the Brief communication paper, we kept it in one figure and did not separate it.



Revised Fig 1.