Response to the community comments

This manuscript presents a rigorous and timely investigation of lake–terminating glacier dynamics, revealing critical non-linear feedback between proglacial lake levels, ice flotation, and grounding line flux with important implications for glacier stability and hazard assessment."

Introduction

Some suggestions

- Some references to "marine ice sheet instability" are appropriate, but a clearer distinction between marine vs lake-terminating glacier analogs would help prevent overgeneralization.
- Inclusion of a brief discussion on the limitations of previous models (e.g., neglect of transient lake level changes, hydrostatic effects) would better justify the novelty of the current experiments.

AP: *We do not mention "marine ice sheet instability" in the introduction. We mentioned the difference between marine- and lake-terminating glacier, where distinct characteristic of lake level fluctuations for lake-terminating glacier has been investigated.*

We mentioned in the introduction that transient lake level change is the distinctive feature of lake-terminating glacier and the effects of it has not been investigated. In the revised manuscript, we would further stress upon the fact.

Methods

Experimental design is robust and systematic, with three clear experiments: lake vs land termini, lake level fluctuations, and rapid drainage stress response. The model explicitly isolates hydrostatic effects from climatic forcing and frontal ablation, allowing clean attribution of observed glacier responses to lake interactions.

Some suggestions for improvement

- The flat lake bathymetry assumption is a simplification; discussion of how this may influence flotation thresholds and grounding line flux would improve interpretation.

  AP: *The flat lake bathymetry is considered to isolate the effect of topography. In the discussion, we stated how prograde or retrograde bed affect the glacier dynamics.*

- The exclusion of frontal ablation, calving, and subaqueous melt should be more prominently acknowledged, as these processes are known to be significant drivers of mass loss in lake-terminating glaciers.

AP: *We stated the rationale behind the exclusion of frontal ablation (calving and subaqueous melting) that our aim to isolate the effect of lake level fluctuations on glacier dynamics.*

- Basal hydrology is simplified; consider discussing how subglacial water pressure variability could alter basal drag and modify the response to lake level changes.

AP: *This has been discussed in the discussion section as "The assumption of simplified basal hydrology also limits our ability to capture the full spectrum of ice-lake interactions. Fully coupled ice-hydrology models (Ehrenfeucht et al., 2023; Sommers et al., 2018) could better represent the complex feedbacks between subglacial water pressure, basal sliding, and lake level fluctuations."*

- A sensitivity analysis for key model parameters (ice viscosity, friction coefficients, lake depth) would strengthen confidence in the reported magnitudes of thinning, velocity, and GL flux changes.

AP: *We present most of our results as a difference. Thus, any uncertainty arise from those model parameters would not affect our results.*

- Explicit numerical or functional forms of mass flux and stress calculations could be included in supplementary materials to enhance reproducibility.

AP: *This is part of the ISSM model post-processing script which will be made publicly available once the paper is published.*

Results

Experiment 1 – Lake vs Land Terminating:

- Include quantitative uncertainty ranges for percentage changes; this will help assess significance and real-world relevance.

AP: *We report our results as a difference, and this is beyond the scope of uncertainty quantifications.*

Experiment 2 – Lake Level Fluctuations:

- Consider integrating figures or tables summarizing the scaling relationships between rate/magnitude of lake change and GL flux or ice velocity. This would make key results more digestible.

AP: *We appreciate the comment. This could potentially be done, and we would address that in the revised manuscript.*

Experiment 3 – Rapid Lake Drainage & Stress:

- Mechanistic explanation of stress amplification is strong and well-linked to calving potential.

AP: *Thank you.*

- Quantify the spatial extent of stress perturbations relative to glacier dimensions; this would clarify the impact of drainage events on overall glacier stability.

AP: *The spatial extent of stress perturbation depends on several factors, such as, ice thickness, glacier geomorphology, lake drainage magnitude. We clearly found the stronger response near the terminus which is expected.*

- The link between tensile stress and potential crevasse depth is insightful; however, variability due to ice temperature and rheology should be explicitly discussed.

  AP: *We are conservative in providing that analyses as our model do not consider fracture and damage mechanics.*

Discussion

The discussion successfully links modeled processes to observations in Greenland and High Mountain Asia. The study provides mechanistic insight into flotation thresholds, asymmetry of responses, hysteresis, and upstream propagation effects. The implications for glacier stability, GLOF hazard mitigation, and proactive monitoring are clearly articulated.

- Some arguments could be strengthened by explicitly comparing the magnitude of modeled responses to observed rates of thinning and velocity change in field studies.

AP: *A direct comparison would not be scientific as we focus on only one parameter. However, we discuss our results in the light of observational studies.*

- The potential amplification of effects if calving and subaqueous melt were included should be discussed quantitatively or via a conceptual estimate.

AP: *We intentionally and consciously exclude explicit treatment of calving and subaqueous melting, in part to focus on the sensitivity to lake level and its hydrostatic effects, and in part because the processes of calving into proglacial lakes (style, geometry, rate, appropriate calving law formulation) and the subaqueous melt rates (and relationship to temperature, melting and water stratification) are poorly constrained and would require significant sensitivity testing themselves.*

- Consider discussing how glacier geometry (width, slope, over-deepened basins) interacts with lake dynamics to generalize results beyond the modeled idealized catchment.

AP: *We have mentioned in the manuscript "Future work should prioritise targeted application of our modelling framework to specific glacier systems that are expected to be most vulnerable to ice-lake interaction. Such studies demand good constraint on local boundary conditions; high-resolution topographic data from satellite and airborne surveys are increasingly providing the geometric constraints needed for realistic simulations."*

Conclusions

Concisely summarize the key findings: lake-terminating glaciers thin and accelerate, flotation thresholds are critical, rapid drainage produces stress responses, and gradual drainage stabilizes the glacier. Emphasizes relevance for hazard mitigation and glacier management, with direct applications for High Mountain Asia and Greenland Ice Sheet.

- Could highlight remaining uncertainties, including neglected processes (frontal ablation, subaqueous melt, complex basal hydrology) and how they might modify results.

AP: *The uncertainties and limitations of the paper have been discussed in detail under section 4.4 Model limitations and future research directions*

- Suggest including explicit recommendations for observational campaigns to test model predictions, e.g., monitoring grounding line flux, ice velocity near proglacial lakes, and stress/crevasse formation following lake drainage.

AP: *Providing explicit recommendations without considering other factors into account could be misleading. However, we would add some recommendations from the results of experiment 3.*

Additional General Comments

Consider including schematic diagrams summarizing mechanisms (buoyancy, basal drag, flotation thresholds) to aid readers' conceptual understanding.

AP: *We appreciate this suggestion. We would add a schematic diagram explaining the critical processes occurring at the lake-terminating glacier front.*