Revision of: *The effect of slab touchdown on anticrack arrest in propagation saw tests*

Dear Editors and Reviewers,

Thank you for your thorough review and constructive feedback on our manuscript. We appreciate the opportunity to revise our work based on your comments and suggestions. We carefully considered each point and made corresponding revisions to enhance the clarity, accuracy, and impact of our manuscript.

In this document, we address each remark (*blue, italic*) point-by-point (black). We hope that these modifications adequately address the concerns raised and improve the manuscript. We are grateful for the guidance that the reviewers' expertise has provided and are confident that these changes have strengthened our submission.

Referee #1

The authors present a novel method for analyzing slab touchdown in a Propagation Saw Test (PST) by developing a closed-form analytical model that incorporates mixed-mode loading (compression and shear) to calculate the Energy Release Rate (ERR) from slab deformation and the resulting crack arrest. To streamline the mathematical framework, they divide the slab touchdown progression into three distinct stages, each characterized by linear behavior and representing different phases of crack propagation and interaction with the collapsed weak layer. The model is validated using finite-element and discrete-element methods, providing a more nuanced understanding of avalanche initiation mechanisms.

I enjoyed reading this article. It is well-written, the model is clearly explained, and sensitivity analyses clearly illustrate its contribution to the avalanche field. While I have very few specific comments on the article's content, minor additions could enhance the manuscript. Below is a list of general comments.

Remark 1.1 *Sensitivity Analysis: The article provides a thorough sensitivity analysis examining the impact of various parameters—such as slab thickness, density, weak layer properties, and slope angle—on crack propagation and arrest. Including a summarized list or table of these findings would enhance their accessibility and value to a broader audience.*

We appreciate the reviewer's suggestion and agree that clarity is important. However, summarizing the findings in a table might oversimplify the complex interdependencies of parameters such as slab thickness, density, weak layer properties, and slope angle. To address this, we will revise the manuscript to include clearer summaries within each relevant section, ensuring that the results remain accessible without losing context.

Remark 1.2 *Model Limitations in Capturing Dynamic Processes: Although the study's static model effectively illustrates the effects of slab touchdown, it fails to capture the dynamic processes involved in slope-scale crack propagation during real-world avalanches. While the authors acknowledge that the model does not account for dynamic stages of crack propagation, this limitation should be explicitly emphasized in the discussion or conclusions. In practical terms, crack arrest in real-world avalanches, occurring after the weak layer crack transitions to a dynamic stage, differs significantly from crack arrest that prevents the transition to a dynamic stage. Addressing this distinction is crucial for clarifying the model's applicability and limitations.*

We agree that the model's limitation in capturing dynamic crack propagation in real avalanches is important. We will emphasize this distinction more clearly in the revised discussion and conclusion, highlighting the difference between crack arrest before and during the dynamic stage.

Remark 1.3 *Limited Experimental Validation: While the authors validate the model using numerical simulations, there is limited reliance on direct experimental data to substantiate the model's predictions. The use of experimental data from natural winter snowpack (Bergfeld et al., 2023a, b) is only briefly mentioned in the "Practical Implications" section. To strengthen the manuscript, I recommend relocating the sections that compare the model to data from Bergfeld et al., 2023a, b to the "Methods" and "Results" sections, as this comparison provides the most compelling validation of the proposed model.*

While we provide some discussion of experimental comparisons in Section 4.7, we recognize the importance of better aligning these findings with the broader narrative of the manuscript. We will improve the integration of these comparisons with the methodological framework and ensure they are more clearly referenced earlier in the text. This will help highlight their relevance to the model's validation while maintaining the logical flow of the manuscript.

Remark 1.4 *Complexity and Accessibility: The article's technical language and in-depth mathematical modeling may limit its accessibility to a broader audience, such as those involved in developing "best practice" guidelines for snowpack observation and avalanche testing who could benefit from its insights. To increase its impact, the authors could provide a concise summary of the key results and a more accessible overview, highlighting practical implications and recommendations for application in the field.*

We will revise the conclusion to include a concise summary of key results and practical implications for broader accessibility. Additionally, we aim to seek cooperation with field experts to apply such models in understanding real-world implications. We are looking forward to any exchange here.

Remark 1.5 *Practical Implications Not Fully Explored: While the study offers theoretical insights into crack arrest mechanisms, its practical implications are mostly confined to tentative recommendations for PST geometry. However, as the authors suggest by listing these recommendations, even the optimal geometry for PST remains uncertain, and there is still a lack of understanding of how to interpret test results concerning actual avalanche occurrences. The article would benefit from leveraging its rigorous sensitivity analysis to discuss further how these findings could inform practical avalanche safety strategies and improve real-world decision-making for avalanche risk management.*

We acknowledge the importance of connecting the theoretical insights presented in this study to practical applications in avalanche risk management. In the revised manuscript, we will expand the discussion to address the practical implications of our findings. Specifically, we will highlight how the sensitivity analysis can inform optimal PST geometry and its interpretation. Additionally, we will discuss the limitations and uncertainties associated with translating test results to real-world avalanche occurrences and suggest avenues for improving decision-making strategies in avalanche safety.

Remark 1.6 *Simplification and Assumptions: As noted in the article, the model does not consider frictional sliding during slab touchdown and assumes full contact and stress transfer. In real-world scenarios, frictional effects can be significant, particularly at high slope angles, potentially affecting the ERR and the probability of crack arrest. Although this limitation comes into play at the extreme upper end of the avalanche release slope angle, this and other limitations should be clearly outlined in the discussion or conclusion sections to provide a more comprehensive understanding of the model's constraints and applicability to real avalanche conditions.*

The role of friction during initial contact requires detailed exploration, which we plan to address in future research alongside experimental analyses. We will clarify this limitation in the revised discussion and conclusion.

Remark 1.7 *Detailed hints and remarks in the attached annotated PDF file of the manuscript.*

Thank you for the direct annotations in the manuscript. They are all helpful to increase clarity of the points we want to bring across. We will consider all in the revised version of the manuscript.