Response to RC2

This paper presents a detailed dynamic analysis of two flow-like landslides (Igl Rutsch and Insel) in Brienz/Brinzauls, Switzerland. It introduces a novel GPU-accelerated numerical model (Orin-3D) capable of simulating landslide velocities ranging from moderate (meters/day) to extremely rapid (>5 m/s). The research is innovative, methodologically sound, and well-supported by field data, historical records, and modern monitoring techniques. The study provides significant theoretical and practical contributions to landslide hazard assessment and risk prediction. The paper is well-structured, logically organized, and supported by appropriate figures and references. Overall, the manuscript is of high academic merit and merits publication. Several suggestions are listed below for reference.

1. The paper notes that pore pressure dynamics were not considered in the simulations, which could be significant for clay-rich landslides. A more detailed discussion of this assumption's implications should be added.

Thanks for this important comment, we have updated the discussion to read (new text in bold):

The simulated mass comes to rest due to a combination of spreading (which reduces internal pressure gradients), and changes in the topographic slope angle. Remarkably, it was not necessary to account for pore pressure generation and dissipation to explain the emplacement of the lgl Rutsch failure. ***Most landslides with moderate to rapid velocities, such as earthflows (e.g. Mackey & Roering, 2011), are acutely sensitive to pore pressure dynamics. The fact that we could reproduce many features of lgl Rutsch without explicit consideration of pore pressure suggests its dynamics are different from these events, despite superficial similarities. However, Figure 3 shows that, between Jan 1879 and July 1881, the landslide likely went through seasonal acceleration phases, which are still present in the inclinometer data measured in some of the boreholes (albeit at much smaller magnitudes). This suggests that seasonal accelerations due to pore pressure dynamics may overprint the bulk behaviour, and that this is not captured in our numerical simulations.*** *This could potentially be addressed by employing time-varying parameters in our proposed basal drag law (Eq. [5]), though this would complicate the calibration procedure.*

2. The model does not fully capture the seasonal velocity variations observed in the Igl Rutsch landslide. The authors should explore incorporating time-dependent parameters (e.g., viscous coefficient δ) to better match field observations.

We agree with this comment, and have more clearly highlighted and contextualized this limitation in the updated text above. However, we consider incorporating time dependent parameters beyond the scope of the present work, due to a lack of pore pressure data that could be used to justify the selected values. We therefore prefer to keep our simulations as simple as possible, so that we can interpret the results to infer dynamics.

We updated the paragraph below in section 5.1 to address this important point:

The ability of our new numerical scheme to overcome the computational challenges described above is likely due to a few unique characteristics that govern the emplacement of flowlike landslides. In particular, most source geometries feature a much larger spatial area than height, leading to relatively small internal pressure gradients ($\frac{\partial h}{\partial x}$ and $\frac{\partial h}{\partial y}$ terms in Eq. [1] and [2]), making it acceptable to use relatively large timesteps in the newly implemented implicit timestep scheme. With the model validated and verified (Figure 6 and Figure 3), there is potential to simulate other flowlike landslides of this type, in particular earthflows (e.g. Aaron et al., 2021; Keefer & Jonhnson, 1983; Mackey & Roering, 2011). ***In particular, pore pressure data is occasionally available for these other landslide types, which could justify the use of more complex, time dependent rheological parameters.*** *This will be a subject of future work, and the present implementation fills an important existing gap in the analysis of landslide motion.*

3. A sensitivity analysis of key parameters (e.g., δ and φ) would strengthen the model's interpretability.

This is a great point, and we summarize the results of a sensitivity analysis using the methodology described in Aaron et al. (2019) on Figure 1 below. As can be seen, the friction angle governs the impact area, and restricts the values of φ to ~ 23° to 26°. The viscous parameter mainly governs velocity, and provides the best fit for δ ~= 5e9.

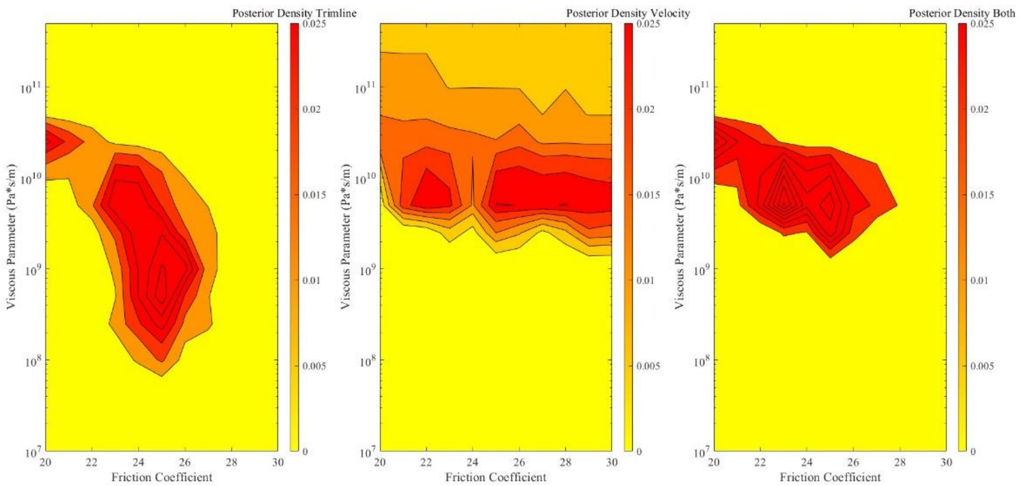

Figure 1: Sensitivity analysis of the key rheological parameters. Left: parameter posterior probability when only the trimline is used. Middle: parameter posterior probability when only the velocity data is used. Right: combined posterior probability density function.