Response to Referee #2 comments

We thank the referee for the constructive assessment and for recognizing the relevance of linking lacustrine paleoseismic records to quantitative ground motion estimates. In response to the main concerns, the revision (i) distinguishes explicitly between parameters constrained at Lake Riñihue and parameters adopted from analogues, (ii) substantially expands the sensitivity analysis, now including elastoplastic PIMY simulations in the Supplement, and (iii) softens the interpretation of the 2D-GMPE differences and of the SSDS thresholds (see the Summary above and the new Section 5.5).

Comment 1

The velocity model for Lake Riñihue relies largely on published studies and analog data from similar lacustrine environments. This limitation reduces the robustness of the results, and the associated uncertainties should be quantified and discussed more explicitly.

We agree that the velocity model is among the main sources of uncertainty, and the revised manuscript now makes the distinction between measured and adopted parameters explicit: bulk density is measured on the studied, unopened cores (Geotek MSCL, 0.5 cm resolution; Molenaar et al., 2021), whereas Vp and Vs are adopted from published analogues, with the reported literature ranges treated as their uncertainty (Section 3.1.2). The BM02-BM07 and flat-layer settings are now revised as sensitivity tests, complemented by the alternative-Vp model (~30% higher amplitudes, identical pattern, so the preferred setting is conservative) and by new elastoplastic PIMY sensitivity runs in the Supplement, which reduce PGA by ~50-60% in the thick eastern sediments while preserving the spatial pattern; the linear results are accordingly presented as upper bounds. Pore-pressure generation, which the total-stress PIMY model cannot represent, is revised as a limitation. All of this is consolidated in the new Section 5.5, and the study by Pamuk et al. (2026) is now cited for the limitation of Vs30 as a site proxy.

Changes in the manuscript:

> **Section 3.1.2:** *"Of the model parameters, bulk density is directly constrained by measurements on the studied (unopened) sediment cores (Section 3.3.1), and available whole-core Vp logs cover only the uppermost meters of Unit 3, whereas no Vs measurements exist for Lake Riñihue; the model velocities of all units were therefore adopted from the analogues and empirical relationships above. We treat the reported literature range of each unit as the uncertainty on the adopted value; the propagation of these velocity uncertainties to the simulated ground motions is addressed by the stepwise property substitutions of Section 3.3.1 and discussed in Section 5.5."*
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> **Section 5.1:** *"...as these mainly rely on Vs30 (and f0) variations as the single proxy for the site amplification term (Castellaro et al., 2008; Pitilakis et al., 2013; Stewart et al., 2014; Pamuk et al., 2026)."*
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> *0.5 and 10 Hz to bracket the basin fundamental frequencies and the dominant input frequencies."*
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> **New Section 5.5 (first paragraph):** *"The main simulations assume linear visco-elastic behavior with constant 5% Rayleigh damping (Section 3.3.1). At the shaking levels imposed by the 1960 and 2010 events, the soft lacustrine sediments are expected to respond nonlinearly: modulus reduction shifts the resonance toward lower frequencies, and increased hysteretic damping attenuates high-frequency motion, thereby lowering the PGA amplification (Kramer, 1996). The linear results therefore represent an upper-bound estimate of the amplification. Supplementary sensitivity simulations using the fully elastoplastic PIMY formulation (Figures S14-S15) indicate that nonlinearity reduces PGA by approximately 50-60% in the thick eastern sediments, most strongly for the higher-amplitude 1960 event, while the localized western-slope peaks and the overall west-east amplification pattern are preserved. We therefore consider the spatial pattern of the response robust, whereas the absolute amplitudes, including the up to approximately twofold exceedance of the GMPE predictions, should be interpreted as upper bounds."*
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> **New Section 5.5 (fourth paragraph):** *"Apart from lake core Vp logs restricted to the uppermost meters of Unit 3 (Section 3.1.2), no velocity measurements exist for Lake Riñihue: the model velocities were adopted from analogue settings and empirical relationships, so the associated literature ranges represent a uncertainty on the absolute amplification. The stepwise unit models (BM02-BM07 and the flat-layer models) impose property variations larger than the plausible uncertainty of any individual unit and preserve both the spatial response pattern and the exceedance of the GMPE predictions, while the alternative Vp model (Table S1; Figures S2-S3) yields a similar pattern with ~30% higher absolute amplitudes. The preferred, consolidated Vp setting is thus conservative with respect to this parameter choice (i.e., it yields the lower of the two amplification estimates), within the linear framework that itself constitutes an upper bound. Future in-situ shear-wave measurements and laboratory characterization of the dynamic properties of these lacustrine units would reduce these uncertainties most directly."*

Comment 2

The finding that the 2D simulations produce PGA and PGV values up to twice those predicted by the GMPEs is *important. However, since these results are not validated using local strong-motion recordings or independent geophysical observations, the conclusions should be presented more cautiously.*

We agree. No strong-motion recordings exist within or near the lake basin for either event. The revised manuscript therefore frames the 2D results as model-based estimates rather than validated predictions, and the quantitative statement is softened throughout to "up to approximately a factor of two", explicitly labeled an upper bound. The elastoplastic sensitivity runs are central to this reframing: they show the linear simulations overestimate absolute PGA where nonlinear damping is expected, while the spatial pattern (western-slope peaks; west-east contrast) is preserved, i.e., the absolute amplitudes are uncertain upper bounds, whereas the geometry- and impedance-controlled spatial trend is robust.

Changes in the manuscript:

> **Abstract:** *"2D linear visco-elastic simulations predict peak ground accelerations (PGA) and peak ground velocities (PGV) that exceed GMPE estimates by up to approximately a factor of two, an upper-bound estimate of the amplification."*
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> **New Section 5.5 (in final paragraph):** *"Moreover, no strong-motion recordings exist within or near the lake basin for either event, so the simulated ground motions and their exceedance of the GMPE predictions are model-based estimates rather than validated predictions."*

Comment 3

The 1960 earthquake lies outside the calibration range of the GMPEs. Although the authors acknowledge this limitation, the implications of this extrapolation and its potential influence on the results should be discussed more thoroughly.

We agree and have expanded this point. The extrapolation affects both the GMPE reference estimates and the target spectra used to scale the input motions (Section 3.2). Because reference predictions and input target spectra share the same extrapolated bedrock-site model, the simulations inherit any bias through their inputs; as the main simulations respond linearly to the input, such a bias scales both sides by the same factor and largely cancels in the exceedance factor and in the spatial amplification pattern (the residual dependence enters only through the nonlinear GMPE site term; Section 3.2), mapping instead onto the absolute ground motion values, which we therefore treat as physical-based estimates rather than precise predictions. Importantly, the conclusions do not rely on the 1960 event alone: the 2010 Mw 8.8 Maule earthquake is part of the calibration dataset of these Chile-specific GMPEs and shows the same first-order behavior. Section 5.5 now adds this context and distinguishes the extrapolation uncertainty from that arising from nonlinear sediment behavior.

Changes in the manuscript:

> **Section 3.2:** *"The 2010 Mw 8.8 Maule earthquake is part of the calibration dataset of these Chile-specific GMPEs, whereas the Mw 9.5 magnitude of the 1960 event exceeds their strict calibration range, so that the corresponding estimates, and the target spectra derived from them (Section 3.3.2), are extrapolations. The models nevertheless demonstrate reasonable scaling behavior for large megathrust events through their bilinear magnitude functions (Montalva et al., 2017; Montalva et al., 2022), and the implications of this extrapolation are discussed in Section 5.5."*
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> **New Section 5.5 (final paragraph):** *"This extrapolation, however, affects both sides of the comparison, because the same bedrock-site model, without the site term, also defines the target spectra of the input motions (Section 3.3.2): the simulations inherit any bias in the extrapolated value through their inputs, and since the main simulations respond linearly to the input, such a bias would scale the simulated ground motions and the GMPE predictions by the same factor. The exceedance factor and the spatial amplification pattern are therefore largely insensitive to this extrapolation, with a residual dependence entering only through the amplitude-dependent (nonlinear) site term of the GMPEs (Section 3.2); the bias instead maps essentially onto the absolute ground motion values. This uncertainty is independent of, and additional to, the nonlinear-sediment effects discussed above. Moreover, no strong-motion recordings exist within or near the lake basin for either event, so the simulated ground motions and their exceedance of the GMPE predictions are model-based estimates rather than validated predictions. The consistency of the first-order behavior between the extrapolated 1960 event and the within-calibration 2010 event supports the robustness of the spatial conclusions."*

Comment 4

In particular, the number of sediment cores used for SSDS analysis is relatively small. Consequently, the proposed PGA threshold values should be presented as preliminary findings rather than definitive conclusions.

We agree. The SSDS threshold values are now labeled preliminary in the Abstract, in Section 5.3.2 and in the Conclusion, with the limited core number stated. We also clarify that the mechanistic interpretation rests on the combination of the exploratory regressions, the 2D-simulated ground motions and the distinct physical mechanisms of SSR (velocity/duration-controlled remobilization) and SSDS (acceleration-driven KHI deformation), rather than on individual coefficient values. More importantly, the preliminary result also reflects the uncertainties of the ground motion models themselves (Section 5.5): the robust output is the relative relation, with thicker and/or more intense SSDS at higher PGA and deeper SSR at higher PGV, rather than the absolute values.

Changes in the manuscript:

> **Section 5.3.2:** *"Given the limited number of SSDS-bearing cores (Section 4.4.2) and these model uncertainties, the derived threshold values should be regarded as preliminary; the robust result is the relative relation, with thicker and/or more intense SSDS at higher PGA and deeper SSR at higher PGV, rather than the absolute values (Section 5.5)"*
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> **Section 5.3.2:** *"In conclusion, our results suggest that in a uniform stratum, PGA acts as both the threshold parameter for SSDS type and a predictor of deformation thickness, with the threshold values themselves remaining preliminary given the limited core dataset."*
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> **Abstract:** *"...whereas SSDS is controlled by PGA, with different, albeit preliminary, thresholds for progressively increasing deformation types, while PGA also predicts deformation thickness."*

Comment 5

Several grammatical errors and awkward sentence constructions remain in the manuscript. Examples include phrases such as "SSR initiate" and "while also predicts deformation thickness," which should be revised for clarity and correctness.

Thanks for identifying these problems. We corrected the cited sentences, revised the figure captions, and proofread the complete manuscript for grammar, agreement, terminology, and sentence structure.

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