Response to reviewer RC1:

We thank the reviewer for the suggestions to improve the document. At the same time, we regret that the exposition was not clear enough for the reviewer to fully understand the key aspect of the document's contribution and novelty.

What is novel about our approach is the combined application of a fully probabilistic risk assessment methodology at a city level, along with a very high resolution in the exposure model. By fully probabilistic we mean that our main objective is to obtain the final, unconditional, probability distribution over all potential seismic consequences (we study physical damage, economic losses, and casualties), and not the distribution conditioned to a particular seismic scenario or event, as is commonly found in the literature. On the one hand, we calculate consequences event by event considering thousands of seismic scenarios, taking care of the spatial correlation of the seismic intensity measures in each scenario. On the other hand, models at a city level are scarce, the more so for finer resolutions. Our resolution is the finest, as we consider each individual building unit in the city with its particular characteristics. Additionally, our counterfactual scenario analysis provides valuable insights into the potential impact of changes in building classes on the distribution of annual losses for various consequence variables. The comprehensive information provided by this fully probabilistic approach, i.e. annual distribution of physical damage, economic losses and/or casualties, is significantly useful for decision makers, serving as a substantial complement to the risk metrics derived from scenario-based evaluations. In fact, as acknowledge in this manuscript, part of this study is required and funded by the Chilean National Science Foundation (ANID) to work closely with the Ministry of Housing (MINVU) to provide these findings as tools to orient decision making at the public policy level.

While extensive research can be found regarding risk assessment in urban areas around the world (De Risi et al., 2019; Basaglia et al., 2018) and also South America (Villar-Vega and Silva, 2017; Feliciano et al., 2023) and Chile (Hussain et al. 2020; Baquedano et al., 2023; Geiß et al., 2023; Gómez et al., 2023), which include significant advancements in the exposure models, and fragility, most of them share a common denominator: **they are conditioned to a specific seismic event**. For example, the first two studies recommended by the reviewer (https://doi.org/10.1029/2021EF002388, https://doi.org/10.1177/87552930221134950,) emphasize high-resolution exposure models, but within the constraints of a particular seismic scenario. Similarly, another study (https://doi.org/10.3389/feart.2020.575048) provides counterfactual analysis but is also conditioned to a specific scenario. In contrast, risk studies considering the temporal distribution of seismic events are limited, mainly because of the high computational cost involved related to the sampling of thousands of earthquake rupture scenarios and subsequent ground motion scenarios. Although there are some examples globally and within South America, including Chile (Yepes-Estrada and Silva, 2017; Petersen et al., 2018), there's a significant gap in progressing risk assessment methodologies to encompass multiple earthquake scenarios.

While recognizing the value of risk assessment conditioned to specific scenarios, especially in risk communication, we emphasize the benefits of a fully probabilistic approach, i.e., considering multiple seismic events and calculating consequences event-by-event.

First, by assessing consequences of a seismic scenario with a specific average return period, and then aggregating losses through classical PSHA, does not take into consideration the spatial correlation of the intra-event residuals (Jayaram and Baker 2009), nor the correlation of loss ratio between buildings of the same vulnerability class, even if the intensity measures were initially spatially and spectrally correlated.

Second, the consequences of an earthquake scenario that has an average return period of *X* years are not the same as the consequences that have an average return period of *X* years (Ellingwood, 2009). Furthermore, using Poisson's assumption, those consequences that have a return period of *X* years are expected to be exceeded on average at least once, which is not the same as the probability of having that consequence only once.

Third, to consider both aspects appropriately, a fully probabilistic event-based approach is needed, where losses are calculated event by event, which leads to a loss exceedance curve representative of the whole exposure model (Silva et al., 2015). This approach leads to higher probabilities of exceeding large losses (e.g., Park et al., 2007; Silva et al., 2014). Additionally, this effect is also present in hazard studies. When considering multiple seismic scenarios, seismic hazard estimates tend to be higher, because in "earlier studies the ground-motion variability was either completely neglected or treated in a way that artificially reduced its influence on the hazard" (Bommer & Abrahamson, 2006). Bommer & Crowley (2006) also emphasizes that to capture the variability in ground motion, the recommended approach involves modeling a "large number of earthquake scenarios that sample the magnitude and spatial distributions of the seismicity, and also the distribution of ground motions for each event".

We use Monte Carlo simulations to generate a stochastic synthetic earthquake catalog, where thousands of earthquakes magnitudes are sampled from a truncated exponential distribution with parameters based on the most updated Chilean recurrence model (i.e. Guttenberg-Richter law). Also, each earthquake magnitude is spatially sampled from a uniform distribution in the subduction interface defining a hypocenter for each sample, and therefore defining a rupture surface. Next, for each rupture of the earthquake catalog, the ground motion model is sampled to obtain spatially distributed intensity measures for each scenario, and therefore its consequences. Finally, using the total probability theorem, all the scenarios are integrated, enabling us to compute annual consequence distributions that reflect the city's seismicity (Crowley and Bommer, 2006; Baker and Cornell, 2008; Jayaram and Baker, 2010; Allen et al., 2022; Ferrario et al., 2022).

In addition to employing a fully probabilistic approach, we developed a highly detailed exposure model. The actual exposed building stock of the city is constructed starting from each building unit within a city block, utilizing the most detailed publicly available information. For each building unit within a city block, we assign a building class based on available data such as material, use, year of construction, etc. Consequently, we estimate the consequences event by event, taking into account the specific seismic intensity measure for each census block in every seismic scenario, as well as per square meter built for each building class within that block.

Our counterfactual scenario analysis is just one example of what models of this sort can deliver. The scenarios discussed in this research are meant to reflect shifts not in the city's expansion but in its densification or changes in land use. This provides valuable insights regarding the potential impact that such changes may generate in terms of the annual losses' distribution calculated for the different consequence variables between the current exposure and the counterfactuals. The results provided by the counterfactuals are not trivial, primarily because they depend on the current exposure and hazard, which is a real city case, and second, because the result is not the same across different consequence variables. On the one hand, the impact of changing the predominant building class (which represents 27% of the total exposed built area), has significant but different impact on physical damage, casualties and economic losses (48%, 80% and 17-24%). However, changing the second predominant building class (which represents 21% of the exposed built area) has an almost negligible impact on the analyzed consequence variables. These results are not trivial and can significantly impact the decisions on promoting new constructions in areas currently dominated by one building class or another.

In summary, our research aims to address a significant gap in current seismic risk assessment studies. We adopt a comprehensive probabilistic approach by considering thousands of seismic scenarios and calculating losses event-by-event. Our focus is on assessing probability distributions for various consequence variables within specific time frames in urban environments, including different counterfactual scenarios. This effort enhances our understanding and contributes to advancing seismic risk assessment methodologies, providing a valuable complement to scenario-based studies.

Although we are not providing a particular new methodology for seismic risk assessment, **we are integrating the different, state-of-the-art pieces involved in a fully probabilistic risk assessment,** at a city level, along with a very high resolution in the exposure model. We provide unique results on expected consequences (i.e. physical damage, economic losses and casualties) related to seismic risk in the San Antonio study area. We firmly believe that decision makers such as city planners, construction sector regulators, and insurance regulators, urgently require information on annual distributions of an array of disaster consequence variables (Smith, 2004). Many decisions require a full risk assessment, i.e., consideration of the whole probability distribution for any timeframe. This is the case for example of the insurance industry, where specific percentiles of the loss distribution or the mean (expected losses) are considered relevant risk measures, among others (Goda et al., 2015; Yoshikawa and Goda, 2014). Moreover, with the complete consequence distribution at ones' disposal, one can derive numerous risk metrics, including average return periods, probability of exceedance within a time frame, etc.

Regarding the reviewer's specific comments, they could be effectively addressed in a revised manuscript, as they mainly involve clarifying points rather than indicating methodological or technical deficiencies. Furthermore, we believe that in a revised version, we could clarify the aspects that concerned the reviewer regarding novelty and contribution, which were not sufficiently clear in the previous version. Should the editor invite us to submit a revised version of the manuscript, we would gladly provide a detailed response to the reviewer's specific comments.

Allen, E., Chamorro, A., Poulos, A., Castro, S., de la Llera, J. C., & Echaveguren, T. (2022). Sensitivity analysis and uncertainty quantification of a seismic risk model for road networks. *Computer-Aided Civil and Infrastructure Engineering*, *37*(4), 516-530.

Baker, J. W., & Cornell, C. A. (2008). Uncertainty propagation in probabilistic seismic loss estimation. *Structural Safety*, *30*(3), 236-252.

Baquedano-Juliá, P., Ferreira, T. M., Arriagada-Luco, C., Sandoval, C., Palazzi, N. C., & Oliveira, D. V. (2023). Multi-vulnerability analysis for seismic risk management in historic city centres: an application to the historic city centre of La Serena, Chile. *Natural Hazards*, 1-44.

Basaglia, A., Aprile, A., Spacone, E., & Pilla, F. (2018). Performance-based seismic risk assessment of urban systems. *International Journal of Architectural Heritage*, 12(7-8), 1131-1149.

Bommer, J. J., & Abrahamson, N. A. (2006). Why do modern probabilistic seismic-hazard analyses often lead to increased hazard estimates?. *Bulletin of the Seismological Society of America*, *96*(6), 1967-1977.

Bommer, J. J., & Crowley, H. (2006). The influence of ground-motion variability in earthquake loss modelling. *Bulletin of earthquake engineering*, *4*, 231-248.

Crowley, H., & Bommer, J. J. (2006). Modelling seismic hazard in earthquake loss models with spatially distributed exposure. *Bulletin of Earthquake Engineering*, *4*, 249-273.

De Risi, R., Penna, A., & Simonelli, A. L. (2019). Seismic risk at urban scale: the role of site response analysis. *Soil Dynamics and Earthquake Engineering*, *123*, 320-336.

Ellingwood, B. R. (2009). Assessment and mitigation of risk from low-probability, high-consequence hazards. *Australian Journal of Structural Engineering*, *9*(1), 1-7.

Feliciano, D., Arroyo, O., Cabrera, T., Contreras, D., Valcárcel Torres, J. A., & Gómez Zapata, J. C. (2023). Seismic risk scenarios for the residential buildings in the Sabana Centro province in Colombia. *Natural Hazards and Earth System Sciences*, 23(5), 1863-1890.

Ferrario, E., Poulos, A., Castro, S., de la Llera, J. C., & Lorca, A. (2022). Predictive capacity of topological measures in evaluating seismic risk and resilience of electric power networks. *Reliability Engineering & System Safety*, *217*, 108040.

Geiß, C., Priesmeier, P., Aravena Pelizari, P., Soto Calderon, A. R., Schoepfer, E., Riedlinger, T., ... & Taubenböck, H. (2023). Benefits of global earth observation missions for disaggregation of exposure data and earthquake loss modeling: evidence from Santiago de Chile. *Natural Hazards*, 119(2), 779-804.

Goda, K., Wenzel, F., Daniell, J., Beer, M., Kougioumtzoglou, I. A., & Patelli, E. (2015). Insurance and reinsurance models for earthquake. *Encyclopedia of earthquake engineering*, 1184-1206.

Gómez Zapata, J. C., Zafrir, R., Pittore, M., & Merino, Y. (2022). Towards a Sensitivity Analysis in Seismic Risk with Probabilistic Building Exposure Models: An Application in Valparaíso, Chile Using Ancillary Open-Source Data and Parametric Ground Motions. *ISPRS International Journal of Geo-Information*, 11(2), 113.

Hussain, E., Elliott, J. R., Silva, V., Vilar-Vega, M., & Kane, D. (2020). Contrasting seismic risk for Santiago, Chile, from near-field and distant earthquake sources. *Natural Hazards and Earth System Sciences*, 20(5), 1533-1555.

Jayaram, N., & Baker, J. W. (2009). Correlation model for spatially distributed ground-motion intensities. *Earthquake Engineering & Structural Dynamics*, *38*(15), 1687-1708.

Jayaram, N., & Baker, J. W. (2010). Efficient sampling and data reduction techniques for probabilistic seismic lifeline risk assessment. *Earthquake Engineering & Structural Dynamics*, *39*(10), 1109-1131.

Park, J., Bazzurro, P., & Baker, J. W. (2007). Modeling spatial correlation of ground motion intensity measures for regional seismic hazard and portfolio loss estimation. *Applications of statistics and probability in civil engineering*, *2*, 1-8.

Petersen, M. D., Harmsen, S. C., Jaiswal, K. S., Rukstales, K. S., Luco, N., Haller, K. M., ... & Shumway, A. M. (2018). Seismic hazard, risk, and design for South America. *Bulletin of the Seismological Society of America*, 108(2), 781-800.

Silva, V., Crowley, H., Pagani, M., Monelli, D., & Pinho, R. (2014). Development of the OpenQuake engine, the Global Earthquake Model's open-source software for seismic risk assessment. *Natural Hazards*, *72*, 1409-1427.

Silva, V., Crowley, H., Varum, H., & Pinho, R. (2015). Seismic risk assessment for mainland Portugal. *Bulletin of Earthquake Engineering*, *13*, 429-457.

Smith, W. (2004). The decision support model for risk management: a conceptual approach. *Bulletin of the New Zealand Society for Earthquake Engineering*, *37*(4), 149-155.

Villar-Vega, M., & Silva, V. (2017). Assessment of earthquake damage considering the characteristics of past events in South America. *Soil Dynamics and Earthquake Engineering*, 99, 86-96.

Yepes-Estrada, C., & Silva, V. (2017, January). Probabilistic seismic risk assessment of the residential building stock in South America. *In 16th World Conference on Earthquake Engineering*.

Yoshikawa, H., & Goda, K. (2014). Financial seismic risk analysis of building portfolios. *Natural Hazards Review*, *15*(2), 112-120.