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Scenario-based Probabilistic Tsunami Risk Analysis for Coquimbo Bay

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Scenario-based tsunami risk assessment provides valuable insights into the socio-economic consequences of a specific scenario. Although it is focused on a specific scenario or a range of scenarios, this type of analysis can still encompass uncertainty characterisation.

Hazard: Focusing on Coquimbo Bay, which was affected by the 2015 Ilapel tsunami, we demonstrate how the uncertainties are quantified and propagated from the tsunami source level all the way towards risk metrics such as the economic losses. We have chosen a range of near-field tsunami scenarios with moment magnitude between 8.6 <Mw <9.3 from a subduction interface zone on the Nazca–South American plate interface running parallel to the Chilean coastline. We have worked with a large set of stochastic scenarios generated compatible with the scaling laws, with variable slip distribution according to a prescribed correlation structure. We have estimated the seismicity rate through different sources: paleo seismic data, historical catalogue, and moment balancing and have combined the resulting probability distributions through a logic tree approach. The weights of the logic tree are assigned through a Bayesian model class selection procedure as related to the log-evidence calculated for each model. This will lead to scenario-based hazard curves with confidence intervals for different points of interest in the port city of Coquimbo.

Vulnerability: Based on the exposure model for Coquimbo, we have identified two different predominant building categories in Coquimbo, namely the low-rise mixed (wood and masonry) building type and the high-rise residential buildings. For the first category, we have used empirical fragility curves for a similar building type in Dichato and damaged by the Chile 2010 and have characterised the epistemic uncertainty for these fragility curves. We have derived the vulnerability curves and their confidence band through convolution of the fragility curves and the consequence models.

Risk: We demonstrate how hazard and vulnerability curves and their confidence intervals can be convolved to obtain loss curves for certain locations of interest and how this information can be processed to derive scenario-based risk maps for Coquimbo for different return periods.

We conclude by demonstrating the importance of a thorough characterization of uncertainties and their propagation from the tsunami source towards the estimation of the economic losses. This provides important insights about the relative sensitivity of tsunami risk to different sources of uncertainty.