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Deformation and Tsunami Inundation estimates from published slip distributions: How reliable are they?

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A series of large subduction interface earthquakes along the South American coast caused large tsunamis in recent years. Each of these events, such as the 2010 Mw8.8 Maule and the 2015 Mw8.3 Illapel events, provided novel insights to improve tsunami hazard and risk modeling for the region, in particular due to the amount of data collected during post-seismic/ tsunami surveys reporting on coastal deformation, tsunami inundation, and building stock damage. These data are genuinely relevant to evaluate scenario modeling results supporting general approaches to model the tsunami hazard and risk.

Despite the usefulness of rapidly determined finite-fault slip inversions for tsunami warning systems, the reliability of calculated elastic deformations along the coastline based on these models and subsequently tsunami flow depth and runup estimates might be questionable. We primarily shed light on the possible impact of using various solutions for selected historical events by performing full tsunami scenario calculation. We evaluate the inverted slip model solutions from the perspective of a tsunami modeler, i.e. we compare results of the elastic deformation modelling to observed coastal uplift and tsunami inundation against post-seismic survey data. These are important as coastal deformation strongly affects tsunami inundation results. Secondly, we compare observed data to modeled data from inverted slip distributions to solutions based on simulated slip distributions on the same fault geometries to understand the possible range of outcomes. .

Given an inverted slip distribution, we first map those onto the Slab2.0 subduction interface and then calculate stochastic slip distributions. Thereafter, vertical seafloor/coastline deformations are computed using a triangular elastic dislocation model that captures the complexities of the subduction zone geometry. The deformations serve as initial conditions to a high-resolution numerical model that simulates the tsunami wave propagation and coastal inundations. Parallel computations are applied to overcome the large numerical computational efforts needed. Variable land surface roughness based on land cover data is used to simulate the accurate hydraulics of coastal inundation.

Based on our modelling approach, we find that some published slip inversion models are deficient in modelling observed coastal deformation using an elastic deformation model. Only when including tsunami data for the inversions, these models tend to be better constrained. Without

these data, finite fault slip inversions for local tsunami forecasts might be misleading in spatial inundation estimates as deformation results may be incorrect. This can happen both ways, either underestimating or overestimating tsunami inundations. While there are many additional aspects in the tsunami modelling procedure, this is an important basic aspect.

Our results show that simulating stochastic slip distributions enables to cover the range of possible deformation and inundation results well. This result underlines that this approach is a useful tool to generate local probabilistic tsunami hazard and risk models.