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Modifying stochastic slip distributions based on dynamic simulations for use in probabilistic tsunami hazard evaluation.

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Stochastic slip modelling based on general scaling features with uniform slip probability over the fault plane is commonly employed in tsunami and seismic hazard. However, dynamic rupture effects driven by specific fault geometry and frictional conditions can potentially control the slip probability. Unfortunately dynamic simulations can be computationally intensive, preventing their extensive use for hazard analysis. The aim of this study is to produce a computationally efficient stochastic model that incorporates slip features observed in dynamic simulations.

Dynamic rupture simulations are performed along a transect representing an average along-depth profile on the Tohoku subduction interface. The surrounding media, effective normal stress and friction law are simplified. Uncertainty in the nucleation location and pre-stress distribution are accounted for by using randomly located nucleation patches and stochastic pre-stress distributions for 500 simulations. The 1D slip distributions are approximated as moment magnitudes on the fault plane based on empirical scaling laws with the ensemble producing a magnitude range of 7.8 - 9.6. To measure the systematic spatial slip variation and its dependence on earthquake magnitude we introduce the concept of the Slip Probability density Function (SPF).

We find that while the stochastic SPF is magnitude invariant, the dynamically derived SPF is magnitude-dependent and shows pronounced slip amplification near the surface for M > 8.6 events. To incorporate these dynamic features in the stochastic source models, we sub-divide the dynamically derived SPFs into 0.2 magnitude bins and compare them with the stochastic SPF in order to generate a depth and magnitude dependent transfer function. Applying this function to the traditional stochastic slip distribution allows for an approximated but efficient incorporation of regionally specific dynamic features in a modified source model, to be used specifically when a significant number of slip scenarios need to be produced, e.g. for Probabilistic Tsunami Hazard Analysis (PTHA).

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