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Stochastic Slip Distributions in Seismic Probabilistic Tsunami Hazard Assessment

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Accurate representation of heterogeneous slip is critical in Seismic Probabilistic Tsunami Hazard Assessment (SPTHA) for coastlines close to subduction zones. Stochastic slip distributions are generally used to feed aleatory slip variability into SPTHA. These stochastic slip distributions generally contain self-similar or self-affine slip spectra based on seismological and/or geological observations. However earthquakes such as the 2011 Mw 9 Tohoku earthquake, which contained significant slip concentrated at shallow depth, leads to questions as to whether source parameters based on generic observations across a wide range of fault types and environments is valid for a specific fault.

This presentation looks at the calculation and evaluation of stochastic source models used in SPTHA. Taking the Tohoku region as a case study we compare the variation with depth of stochastic source models against 2D numerical simulations rupture simulations. A metric entitled the Slip Probability Density Function (SPDF) which measures the spatial coverage of slip across the fault plane in an ensemble of slip distributions is used tom compare the ensembles. We show that for a large collection of 2D dynamic rupture simulations for Tohoku region the shape of SPDF varies greatly depending on whether rupture reaches the shallow part of the subduction interface or not. Using this modification, we perform 500 simulations and computed the conditional probability for the maximum tsunami wave height for a M9 earthquake along the eastern Japanese coastline. Compared with the same conditional probability but calculated using a traditional stochastic source, the modified stochastic source returned a higher maximum wave height and hence larger hazard.

However, while the numerical simulations provide insight into the effect that fault geometry and free surface effects play in slip distributions, it also inherently implies a number of assumptions about the state of the subsurface (e.g. slip weakening / strengthening, effective normal stress variation etc.). Consequently comparisons with more complicated rupture models as well as seismological observations will be presented.